Atlas of Technics in Surgery

Thoracic and Cardiovascular

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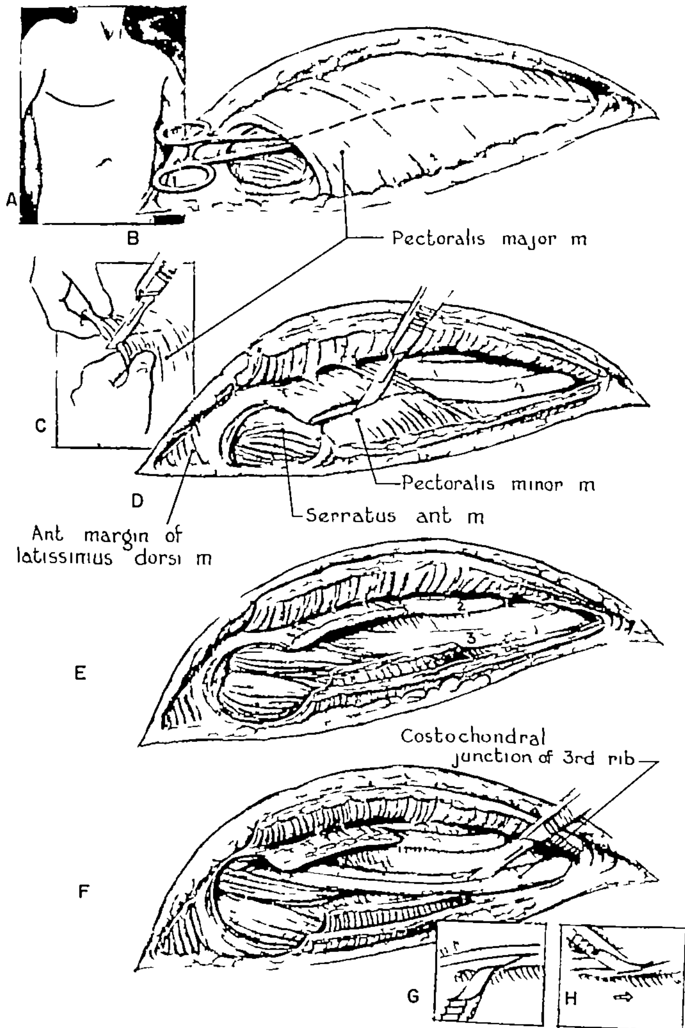
Atlas of Technics in Surgery

Thoracic and Cardiovascular

In the preparation of the Second Edition of the *Atlas of Technics in Surgery* it was immediately apparent that two volumes would be required for its publication. This was necessitated by the large number of new operative procedures, the increase in the reference lists, and the additional discussers, not only for the new operations but also for those previously published in the First Edition.

This Volume 2 contains the thoracic and cardiovascular operations which are generally performed. Accordingly open heart operations are purposely not included because of the limited experience of the author and the highly specialized nature of these operations

It is believed important to reemphasize that each of the operations illustrated was witnessed in the operation room at least once by the artist as it was being performed by the author It is sincerely believed that this is the best way to obtain both anatomic realism and originality of presentation


A
B
Pectoralis major m
C
Pectoralis minor m
D
Serratus ant m
Ant margin of latissimus dorsi m
2
3
E
Costochondral junction of 3rd rib
F
G
H

THE ANTERIOR THORACIC INCISION

A. The right inframammary curvilinear incision extending from the midline of the sternum to the right midaxillary line, is depicted

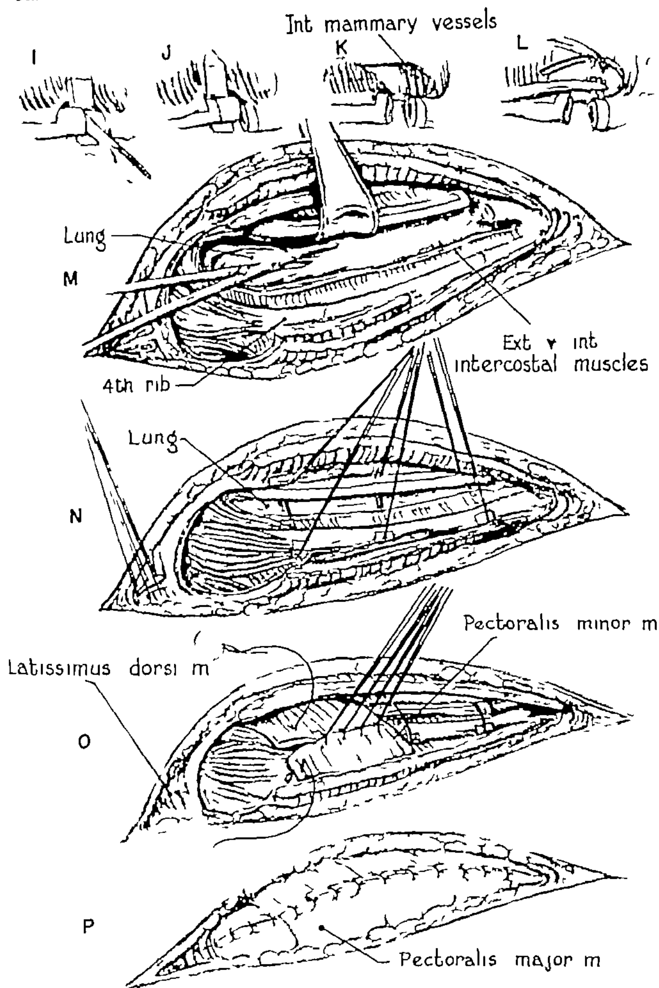
B. By blunt dissection with a pledget of gauze on a ring clamp the pectoralis major muscle is separated from the underlying pectoralis minor muscle, and the proposed line of transection of its fibers is shown by the dotted line

C. Close up to show the compression of the fibers of the pectoralis major concomitant with their severance This particular technic is considered a valuable adjunct in the prevention of excessive blood loss. Intermittent release of the digital compression permits the visualization of bleeding points within the muscle which are clamped as the severance of the muscle fibers proceeds

D The fibroareolar tissue layer overlying the serratus anterior muscle is divided, and the *transection of the fibers of the pectoralis* minor muscle is begun with a scalpel.

E. The transection of the pectoralis major and minor muscles is completed, and the underlying second and third ribs and the intervening external intercostal muscle layer are visible

F G H A longitudinal incision is made through the periosteum overlying the third rib (F), and the lower half of the incised periosteum is separated from the inferior border of the rib with a periosteal elevator (G H).


Int mammary vessels
I
J
K
L
Lung
M
Ext & int
intercostal muscles
4th rib
Lung
N
Pectoralis minor m
Latissimus dorsi m
O
P
Pectoralis major m
Wabnitz

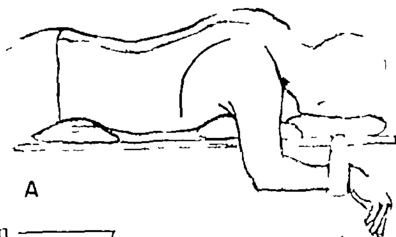
I J K L. A subperichondrial resection of a small segment (2 cm) of the cartilage of the third rib is done (I J) and the adjacent internal mammary vessels are doubly clamped and severed preliminary to ligation with ligatures of 00 silk (K, L)

M The mobilization of the third rib is completed, and the detached but intact external and internal intercostal muscle layers and the related neurovascular bundle are shown The third rib is retracted upward and the opening into the right pleural cavity is extended anteriorly by scissor dissection

N. In the closure of the incision double strands of No 2 chromic catgut are inserted through periosteal "windows" along the inferior border of the fourth rib as pericostal approximating sutures The severed fibers of the latissimus dorsi muscle are united with interrupted sutures of silk (00)

O The rib cage is approximated by tying the previously inserted pericostal sutures, and the transected fibers of the pectoralis minor muscle are sutured with interrupted sutures of 00 silk. In the approximation of the rib cage the intact intercostal muscle layers may be seen overlying the lower half of the anterior surface of the third rib

P The fibroareolar tissue layer and the cut margins of the pectoralis major muscle are sutured with interrupted sutures of 00 silk In this approach as in all other types of thoracic incisions, water seal drainage of the pleural cavity using a No 16 Foley catheter is routinely performed.



A

Trapezius m

Latissimus dorsi m

Rhomboideus major m

Sacrospinalis

5th rib

External intercost

Serratus ant m

B C D

Pectoralis major m

THE POSTERIOR (PRONE) THORACIC INCISION

A. The position of the patient and the outline of the incision are shown

B. The latissimus dorsi muscle is mobilized by blunt gauze dissection, and the direction for transection of the fibers of this muscle is indicated.

C. Bleeding points in the severed margins of the latissimus dorsi muscle are clamped and the clamps are subsequently replaced by suture ligatures of 000 silk. The exposed portion of the trapezius muscle is severed and the intact serratus anterior and rhomboideus major muscles are visible

D The fibers of the serratus anterior and rhomboideus *major muscles are severed*, the mobilized lateral border of the sacrospinalis muscle is retracted posteriorly and the line of incision in the periosteum overlying the anterior surface of the fifth rib is shown. This incision extends from a point 3 to 4 cm beyond the angle of the rib anteriorly to the midaxillary line.

DISCUSSION—DR. CHARLES B RIPSTEIN *Anterior Incision*. The chief advantages of this incision are speed, ease of closure, and minimal disturbance of respiratory and circulatory function. It also has the minor advantages of not interfering with scapular muscles and of having an excellent cosmetic scar

The anterior incision can be used for resections of most segments of the lung, although lower lobe segments may be difficult to expose. It is useful in cardiac surgery and particularly good exposure is obtained when a combined right and left anterior incision are joined by a transverse sternal incision

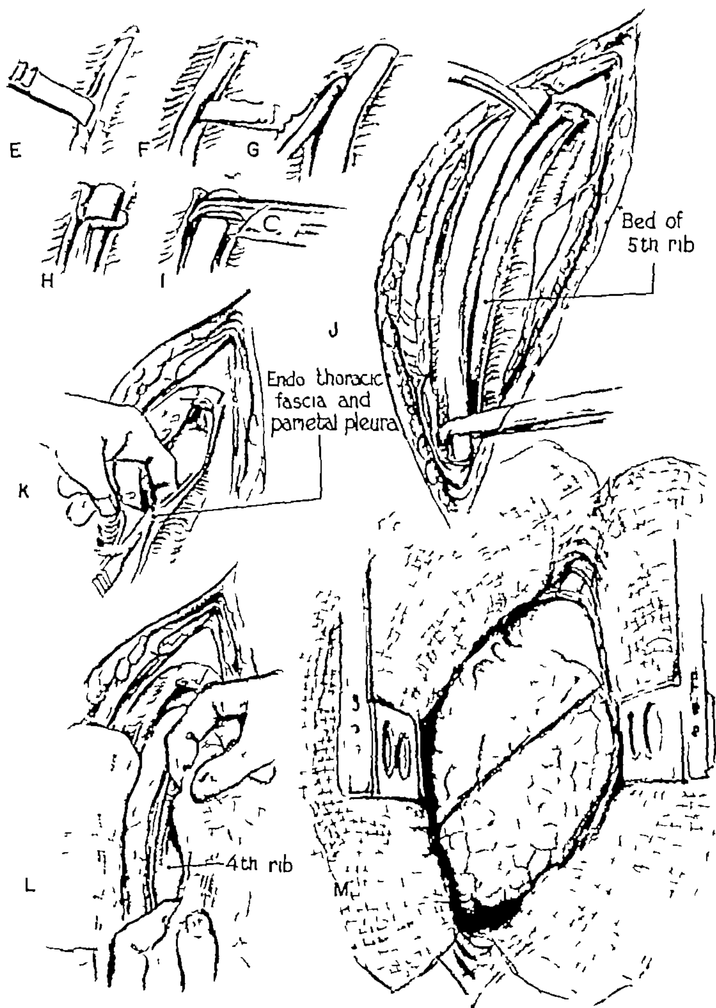
I have used this incision with complete satisfaction in a wide variety of thoracic procedures. Exposure can be widened by combining a unilateral anterior incision with a vertical sternal-splitting incision

In the illustration, a right anterior thoracic incision is shown. I prefer to elevate the chest to a 45 degree angle with a sandbag and suspend the arm from the ether screen. The submammary skin incision is usually extended upward in the midline. There is no advantage to resecting a rib in this incision, such a maneuver leaves a large defect anteriorly and does not provide added exposure If the latissimus dorsi is mobilized laterally and the fibers of the serratus anterior are split in the desired intercostal space, a wide exposure can be obtained.

Closure can be accomplished with interrupted sutures as illustrated or alternatively with a continuous suture. In females, when the breast has been elevated from the chest wall, a submammary drain is advisable to prevent a collection in the submammary space. I feel strongly that, although it is not shown, intercostal tube drainage to an underwater seal is mandatory in all thoracotomies.

Posterolateral Incision. This is the standard thoracotomy incision in most clinics. It offers the widest exposure for unilateral lesions. Its only disadvantage is the dependant position of the nonoperated side which makes respiratory exchange more difficult in poor risk patients. Where high exposure is required, the posterior limb of the incision must be extended into the parascapular area and the scapula mobilized by dividing the trapezius and rhomboid muscles This step is not necessary if the chest is entered below the sixth rib

The illustrations show resection of the sixth rib but this incision may enter *the chest anywhere from* the third to the tenth rib Removal of a rib is optional This is seldom necessary in children where wide re


E
F
G
H
I
C
J
K
L
M
Bed of
5th rib
Endo thoracic
fascia and
parietal pleura
4th rib
Wabi

E F G H I Close up views to show the separation of the periosteum from the rib prior to its resection.

J The rib is transected posteriorly and elevated from its bed prior to its transection anteriorly

K. The right pleural cavity is entered through the bed of the fifth rib and, with a scalpel, the incision in the endothoracic fascia and parietal pleura is extended anteriorly

L, M The rib margins and the soft tissues of the incisional wound are covered with moist gauze pads (L) and protective moist toweling (M) prior to the insertion of a self retaining rib retractor for the exposure of the intrapleural viscera. In the closure of this incision, the same basic principles of technic as previously described are followed.

DISCUSSION—DR. RIPSTEIN (cont.)

traction is possible without producing fracture In adults, I prefer to enter the chest through an intercostal space and divide the posterior portions of adjacent ribs to permit wide retraction.

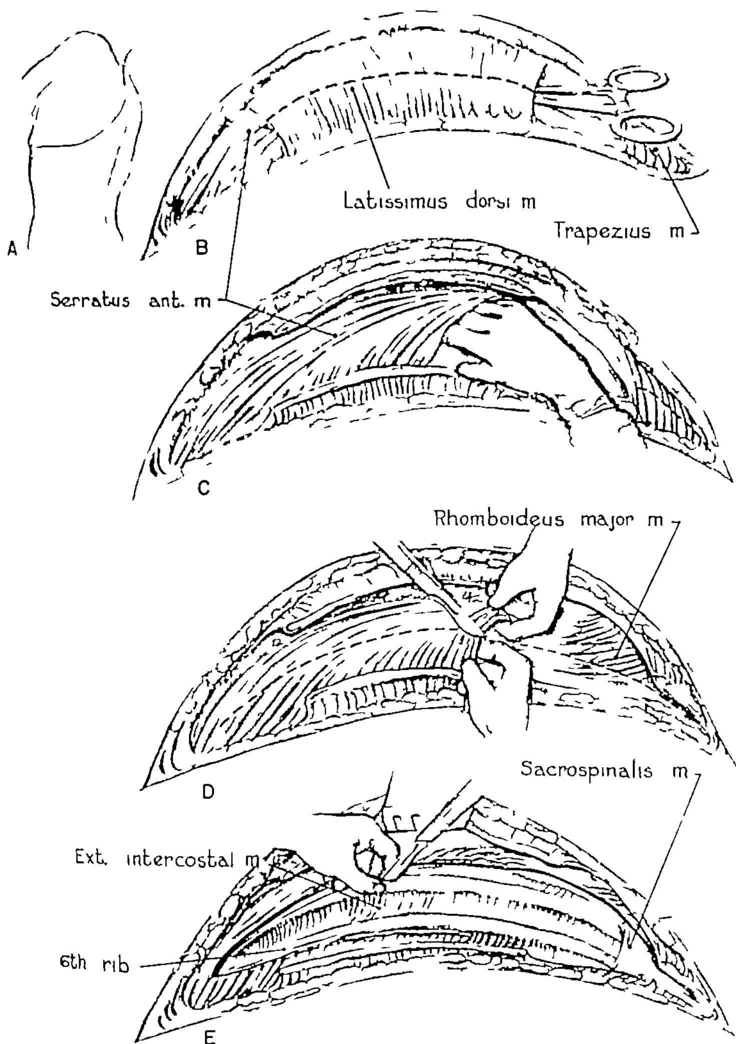
Closure is well illustrated again I recommend intercostal tube drainage

Thoracoabdominal Incision. Combined thoracoabdominal incisions offer magnificent exposure in dealing with lesions involving lower thoracic, upper abdominal, and retroperitoneal organs. On the left side, the lower esophagus, diaphragm, stomach, spleen, colon kidney adrenal aorta, and sympathetic chain are well exposed. On the right side, the diaphragm, liver biliary tract, duodenum, vena cava, kidney and adrenal are readily accessible

The right thoracoabdominal incision is well illustrated. The abdominal portion may be extended to the midline and the right rectus muscle completely divided to obtain maximum exposure. The details of closure are most important, and a meticulous anatomic reconstruction is desirable. I have found it advantageous to leave a covering of fascia and areolar tissue over the costal arch and to approximate the divided cartilage by fine interrupted sutures through this layer

Posterior Incisions. The advantages of this approach are two first, it permits the operated side to be dependent, an advantage when there is a great deal of tracheobronchial secretion or exudate, and second, it does not interfere with expansion of the nonoperated lung. The disadvantages are the inconvenience of posturing the patient and the inadequate exposure of certain areas in the anterior chest and mediastinum.

This incision is used chiefly in resection for tuberculosis, but it has not attained the widespread popularity of the posterolateral approach.


Latissimus dorsi m
Trapezius m
A
B
Serratus ant. m
C
Rhomboideus major m
D
Sacrospinalis m
Ext. intercostal m
6th rib
E

THE POSTEROLATERAL THORACIC INCISION

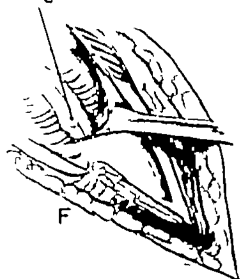
A. The curvilinear posterolateral incision, extending from the anterior axillary line posteriorly and upward, to a point midway between the vertebral border of the scapula and the thoracic spine, is outlined and crosshatched to facilitate later closure.

B. The latissimus dorsi muscle is mobilized by blunt gauze dissection, and the line of transection of its fibers is indicated by the dotted line.

C. The transection of the latissimus dorsi muscle is completed, and the right hand of the surgeon is inserted upward beneath the mobilized portion of the serratus anterior muscle to identify the fifth rib In this maneuver the uppermost rib readily palpable is the second. The site of severance of the trapezius muscle is depicted by the dotted line

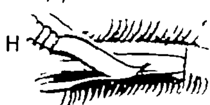
D The fifth rib is identified, and the fibers of the serratus anterior muscle overlying this rib are severed with a scalpel as demonstrated. To avoid minor technical difficulties, the serratus magnus (anterior) muscle should always be severed over the length of the rib that is either mobilized or resected The site of division of the fibers of the rhomboideus major muscle and the adjacent fibroareolar tissue is indicated.

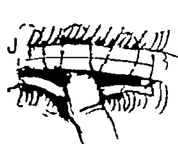
E. A portion of the rib cage and the intervening intercostal muscle layers are shown. A longitudinal incision through the periosteum overlying the exposed portion of the anterior surface of the fifth rib is begun.



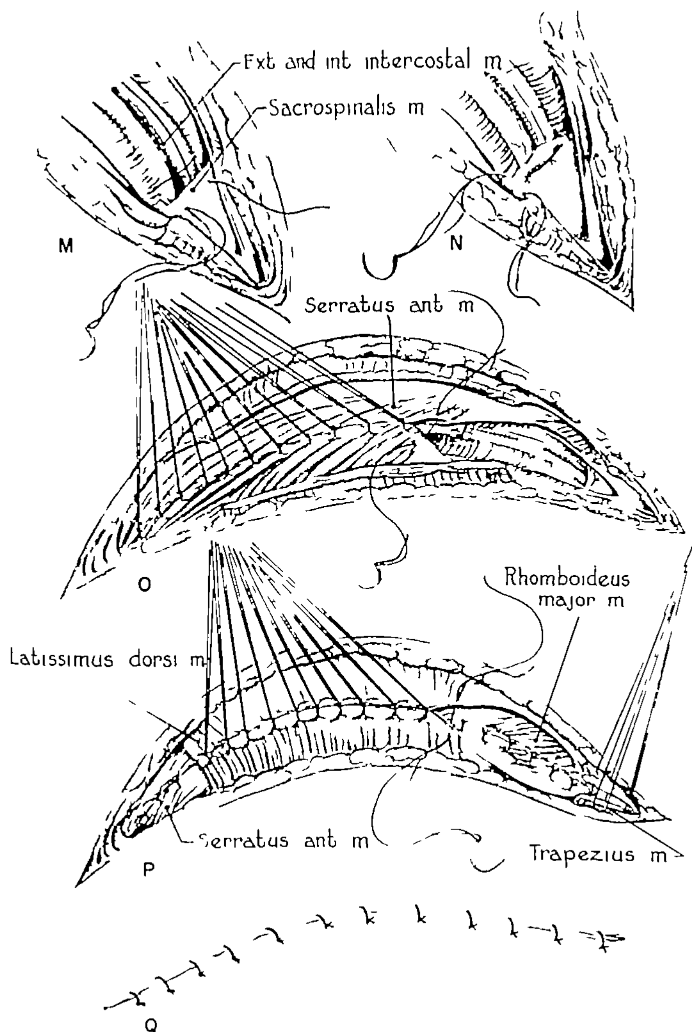








5th rib
Parietal pleura
Lung
Sacrospinalis m
K
L1
L2
L3
L4
Intercostal muscle bundle
6th rib
Trapezius m

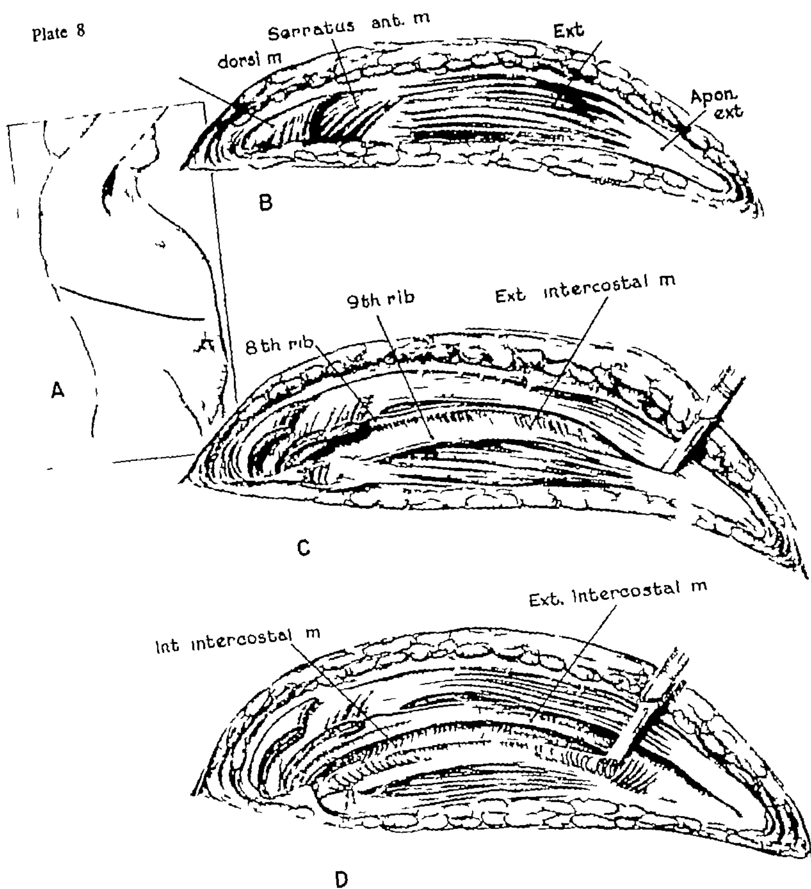

Ext and int intercostal m
Sacrospinalis m
M
N
Serratus ant m
O
Rhomboideus major m
Latissimus dorsi m
Serratus ant m
Trapezius m
P
Q

M N. The pericostal sutures are tied, and the overlap of the lower half of the anterior surface of the fifth rib by the subjacent intact intercostal muscle layers is visible To secure an air tight closure of the pleural cavity the lateral margin of the sacrospinalis muscle is approximated to the subjacent intercostal muscle layers with a mattress suture of 00 silk (M) and two simple interrupted sutures of 00 silk (N).

O The approximation of the rib cage is completed, and the severed fibers of the serratus anterior and the rhomboideus major muscles are sutured with interrupted sutures of 00 silk.

P, Q The latissimus dorsi muscle and the fibroareolar tissue layer overlying the "angle of auscultation" between this muscle and the trapezius muscle and the transected fibers of the trapezius muscle are sutured with interrupted sutures of 00 silk (P) The skin layer is closed with interrupted sutures of 000 silk (Q) Although not demonstrated, in all thoracic incisions in which an entrance into the pleural cavity is made, water seal drainage of the pleural cavity is routinely employed

Plate 8


dorsi m
Serratus ant. m
Ext
Apon. ext
B
A
9th rib
Ext intercostal m
8 th rib
C
Ext. Intercostal m
Int intercostal m
D

THE THORACOABDOMINAL INCISION

The thoracoabdominal incision either right or left, is of distinct value if used when properly indicated. It converts the pleural and the peritoneal cavities into one main cavity and thereby gives excellent exposure of the operative area. However closure of the wound is time-consuming and there is a predisposition to more frequent postoperative complications. Furthermore, it is believed that this type of incision is employed too frequently as a routine when either an abdominal or a thoracic incision alone would suffice for the operation that is planned.

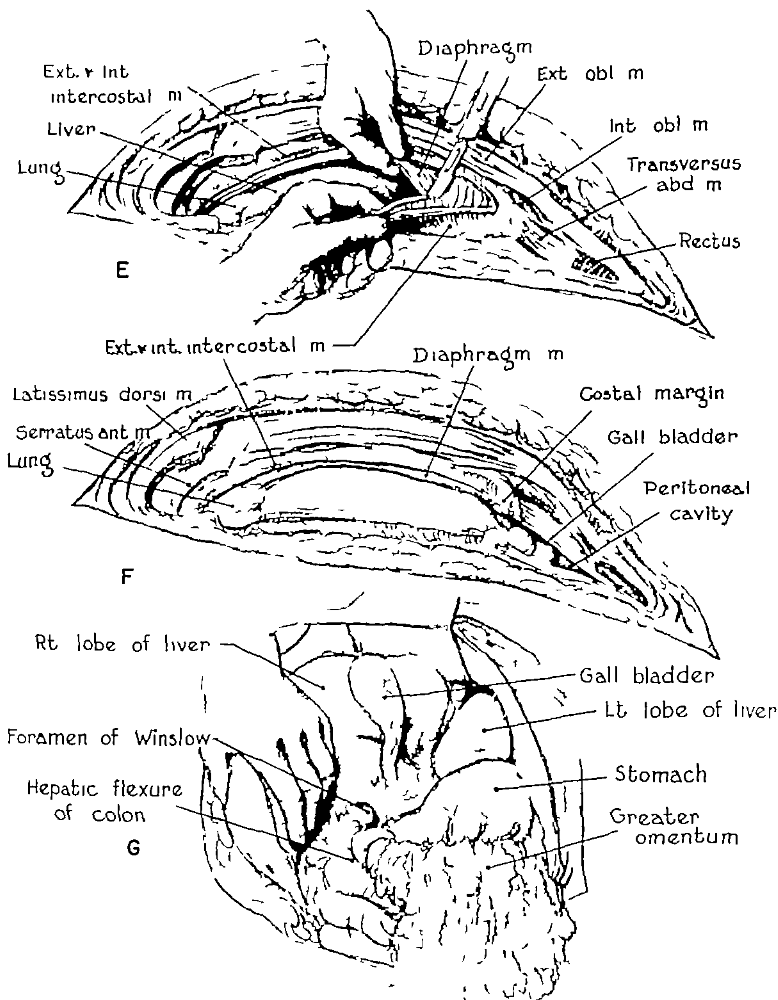
The right thoracoabdominal incision, as depicted in the artist s illustrations, may be particularly useful in reconstructive operations upon the common duct, total excision of the right lobe of the liver and shunt operations between the portal vein and the inferior vena cava The left thoracoabdominal incision may be used effectively in resections of the lower end of the esophagus, total gastrectomy the removal of large and adherent spleens, and in the performance of shunt operations between the splenic and the left renal veins.

A. The incision overlying the eighth interspace and extending across the right costal margin onto the anterior abdominal wall is shown.

B. The incision is deepened through the skin and the subcutaneous fatty tissue layers to expose the underlying musculature of the anterolateral thoracic and the anterior abdominal walls

C. The exposed muscles—the latissimus dorsi, the serratus magnus and the external oblique muscle and its aponeurosis—are severed with a scalpel to expose the eighth and ninth ribs and the intervening external intercostal muscle.

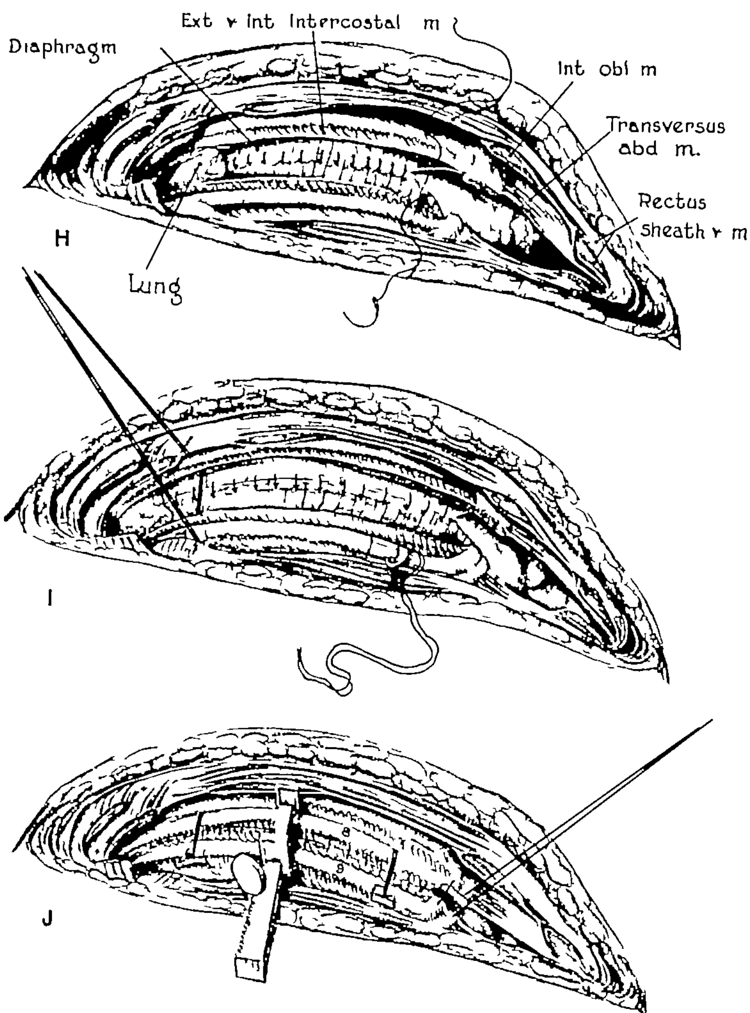
D. The incision is continued through the external intercostal muscle layer and the fibers of the internal intercostal muscle which course in a different plane are depicted


Diaphragm
Ext. & Int
intercostal m
Ext obl m
Liver
Int obl m
Lung
Transversus
abd m
Rectus
E
Ext. & int. intercostal m
Diaphragm m
Latissimus dorsi m
Costal margin
Serratus ant m
Gall bladder
Lung
Peritoneal
cavity
F
Rt lobe of liver
Gall bladder
Lt lobe of liver
Foramen of Winslow
Stomach
Hepatic flexure
of colon
Greater
omentum
G

E. The incision is deepened posteriorly through the internal intercostal muscle, the endothoracic fascia, and the parietal pleura to enter the right pleural cavity. This incision is then extended anteriorly to the costal arch severing the fibers of the internal intercostal muscle and the underlying fibers of the right leaflet of the diaphragm.

F. The incision is continued across the costal arch and through the musculature of the anterior abdominal wall to enter the peritoneal cavity.

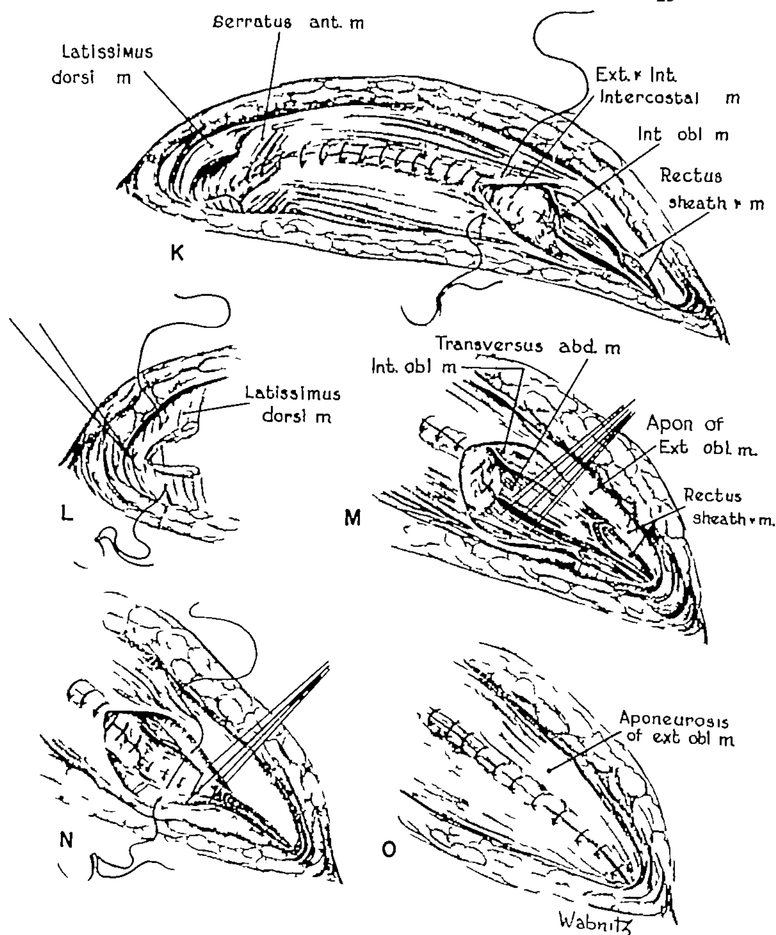
G. The incision is completed and the adequacy of the exposure of the operative field obtained by the conversion of the pleural and peritoneal cavities into a common cavity is shown.


Ext + Int Intercostal m
Diaphragm
Int obl m
Transversus
abd m.
Rectus
sheath + m
H
Lung
I
J

H The closure of the incision is begun by the approximation of the cut margins of the diaphragm with interrupted sutures of silk (00) The surrounding related structures are indicated.

I Two pericostal sutures of double strands of No 2 chromic catgut are inserted preliminary to the approximation of the eighth and ninth ribs Prior to the insertion of these sutures periosteal "windows" are made along the inferior border of the lower or ninth rib This is done to prevent the impingement of the sutures upon the periosteum and thereby possibly lessen both the incidence and/or the severity of post thoracotomy pain

J The rib cage is approximated with a self retaining Bailey-Gibbons rib approximator and the pericostal sutures are tied and cut. The sutures of silk (000) in the intercostal muscle layers are first inserted and, after approximation of the ribs they are then tied and cut. A figure of 8 mattress suture of No 1 braided silk is inserted to unite the cut margins of the costal arch.


Serratus ant. m
Latissimus dorsi m
Ext. & Int. Intercostal m
Int obl m
Rectus sheath & m
K
Latissimus dorsi m
L
Transversus abd. m
Int. obl m
Apon of Ext obl. m.
Rectus sheath & m.
M
N
Aponeurosis of ext obl m
O
Wabnitz

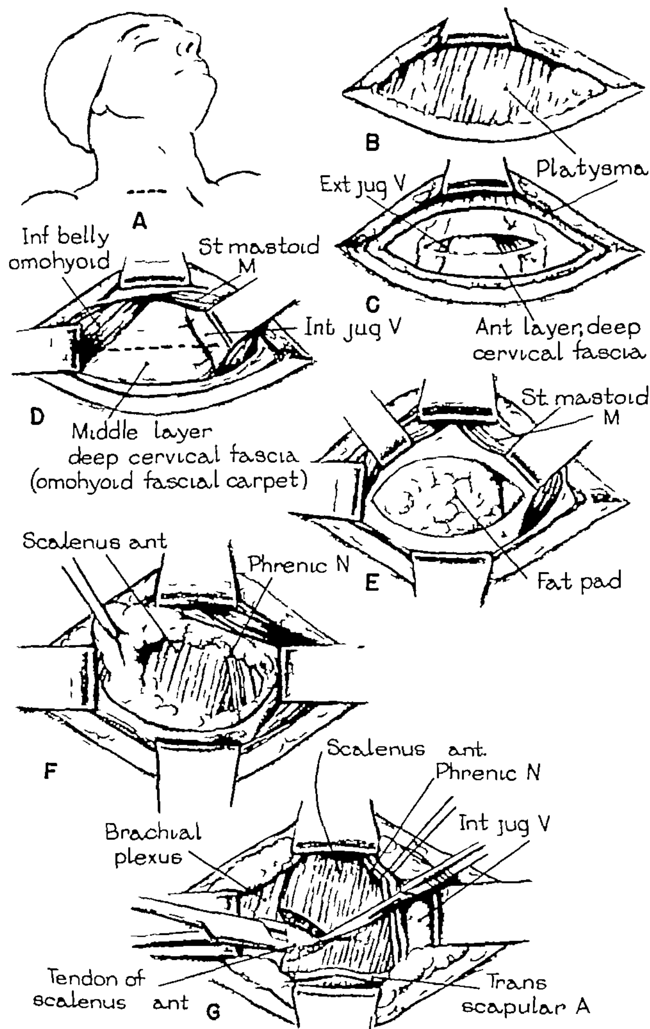
K. The closure of the rib cage is completed and the cut margins of the serratus anterior and the external oblique muscles are sutured with interrupted sutures of silk (00).

L. Close-up showing the approximation of the severed fibers of the latissimus dorsi muscle with interrupted silk (00) sutures.

M. The transversus abdominis muscle layer is approximated with a series of interrupted sutures of silk (000), which are shown inserted but not tied.

N The closure of the transversus abdominis muscle is completed, and the suturing of the internal oblique muscle is begun using sutures of silk (000)

O The closure of the muscle layers is completed by suturing the aponeurosis of the external oblique muscle and the anterior rectus sheath. Although not illustrated in the drawings water seal drainage of the pleural cavity is routinely employed


A
B
Platysma
Ext jug V
C
Ant layer, deep cervical fascia
Inf belly omohyoid
St mastoid M
Int jug V
D
Middle layer deep cervical fascia (omohyoid fascial carpet)
St mastoid M
E
Fat pad
Scalenus ant
Phrenic N
F
Scalenus ant.
Phrenic N
Int jug V
Brachial plexus
Tendon of scalenus ant
G
Trans scapular A

SCALENOTOMY

A The site of the incision overlying the subclavian triangle of the neck is represented by a dotted line. This incision located approximately 4 cm cephalad to the clavicle is bound anteriorly by the posterior border of the sternomastoid muscle and posteriorly by the external jugular vein

B. The skin incision is deepened through the subcutaneous fatty tissue plane to expose the platysma muscle

C. The fibers of the platysma muscle are severed *transversely* and the *incision in the* anterior layer of the deep cervical fascia (investing layer) is visible.

D The clavicular belly of the sternomastoid muscle is retracted anteriorly and the incision in the middle layer of the deep cervical fascia between this muscle and the inferior belly of the omohyoid muscle is indicated by the dotted line

E. The middle layer of the deep cervical fascia (omohyoid "fascial carpet") is incised, and the underlying fat pad a characteristic anatomic landmark, is protruded into the incision.

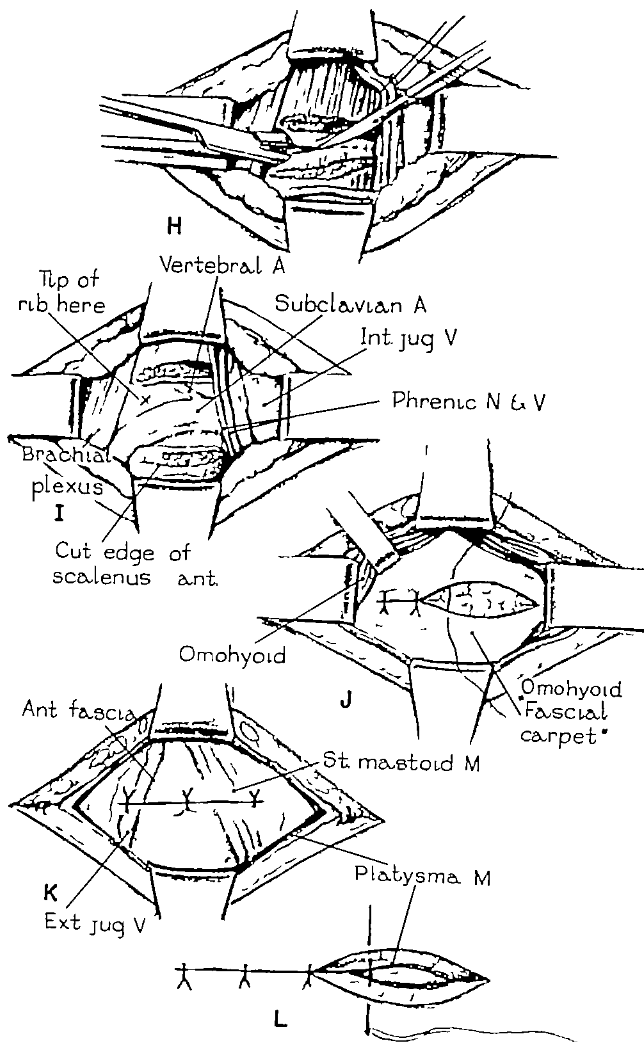
F A portion of the fat pad is held in tissue forceps and displaced posteriorly to expose portions of the scalenus anterior muscle and the phrenic nerve A blood vessel accompanying the nerve may also be seen.

G The lowermost portion of the scalenus anterior muscle is elevated on a clamp and the transection of its fibers in layers is begun The internal jugular vein the transverse scapular vessels, and the phrenic nerve with its accompanying vessel are demonstrable.

DISCUSSION—DR. JAMES T DANIELS. The apparently simple procedure of dividing a muscle such as the scalenus anticus can be appreciated as complex when the important structures lying in proximity to it are visualized. The illustrated technic of approach through the subclavian triangle to the scalenus anticus muscle demonstrates graphically the intricate relationship of these structures to the muscle. It is essential to recall that the entire nerve and blood supply to the upper extremity and one half the nerve supply to the diaphragm are contained within this small area, lying much deeper than it is possible to indicate in a two dimensional illustration. The maneuvering within this confined space is conducted with care in order to avoid injuring the adjacent structures

From the viewpoint of operative surgery alone, relief of disturbing neurovascular symptoms due to compression by scalenotomy is achieved by knowledge of the anatomic relationship of the local and adjacent structures proper exposure, and careful technic. Illustrations designed to serve as a guide for this purpose can be expected to fulfill these requirements *A knowledge of the normal anatomic arrangement* of the elements present in the vicinity of the scalenus anticus muscle is presumed. The need for this knowledge is obvious when consideration is given the fact that lying nearby the scalenus anticus muscle and the structures contained within the precise boundaries of the subclavian triangle are the pleura, the carotid sheath and its contents, and the subclavian and jugular veins. For the careless operator there are many opportunities for disaster

Individual preferences based on experience suggest various considerations for slight alterations of technic. These variations present themselves by anticipating certain anomalies or abnormalities the surgeon may encounter in this region. For example, the anterior approach as illustrated is preferable to the lateral, particularly when a cervical rib of significant proportion is to be resected In this instance a "collar" incision passing 5 to 6 cm. upward and backward from a point slightly above the sternoclavicular articulation is advantageous. This affords exposure of the tendinous clavicular attachment of the sternocleidomastoid muscle. Division of the clavicular attachment provides considerable space and exposure of the proximal portion of the subclavian artery and obviates difficult retraction It is readily sutured with mattress sutures The incision repre-


H
Vertebral A
Tip of rib here
Subclavian A
Int. jug V
Phrenic N & V
Brachial plexus
I
Cut edge of scalenus ant.
Omohyoid
J
Omohyoid
"Fascial carpet"
Ant fascia
St. mastoid M
K
Ext jug V
Platysma M
L

H The transection of the remaining tendinous portion of the scalenus anterior muscle is about to be completed In this regard it is most important to sever completely all of the muscle and tendinous fibers to obtain complete release of the compression effect upon the subjacent subclavian artery

I. The scalenotomy is finished, and the relation of the ends of the completely transected muscle to the surrounding structures is visible

J K. The fat pad is replaced, and the middle (J) and the anterior (K) layers of the deep cervical fascia are approximated with interrupted sutures of fine (0000) silk.

L. The skin is being closed with interrupted sutures of 000 silk Each suture is threaded on a straight cambric or milliner's needle

DISCUSSION—DR DANIELS (cont.)

sented in A, Plate 12, is well suited to this purpose by slight extension anteriorly The sternocleidomastoid and omohyoid muscles are retracted together as shown in Plate 12 (D) Only occasionally is it necessary to sever the omohyoid.

It may be suggested that, when the incision is made closer to the clavicle, the transverse cervical and suprascapular arteries will cross horizontally along the line of approach to the scalenus anticus muscle, particularly its tendinous insertion. These are readily isolated, clamped, severed, and ligated or electrocoagulated. At this low level, the phrenic nerve has, in coursing downward, obliquely crossed the scalenus anticus from its lateral to its medial border The nerve lies medial and may be difficult to find beneath the sternocleidomastoid muscle. It is readily found higher up, and it should be identified, liberated, and displaced medialward where it can be protected for some distance.

In the lateral aspect of the exposure, the brachial plexus is found emerging from behind the scalenus anticus muscle at its lateral border The surgeon must be aware that the distal portion of the subclavian artery lies inferior to the plexus, after arching posterior to the scalenus anticus muscle. This is illustrated in Plate 13 (I) Therefore it is signally important to anticipate possible injury to the subclavian artery Occasionally atheromatous plaques form on the vessel as the result of prolonged compression and irritation. Such plaques have been dislodged and fatal hemorrhage reported. If forceps are to be passed posterior to the muscle, it must be done with great care *My own preference is to free the plexus from* the lateral border of the scalenus anticus muscle to place a cotton strip upon the plexus, and to move it gently medialward as the muscle is divided in the same direction. Direct visualization is thus achieved and injury to the artery avoided. It is considered safer to sever the muscle in a piecemeal manner by grasping a few fibers in tissue forceps and carefully inspecting each group before sectioning with scissors

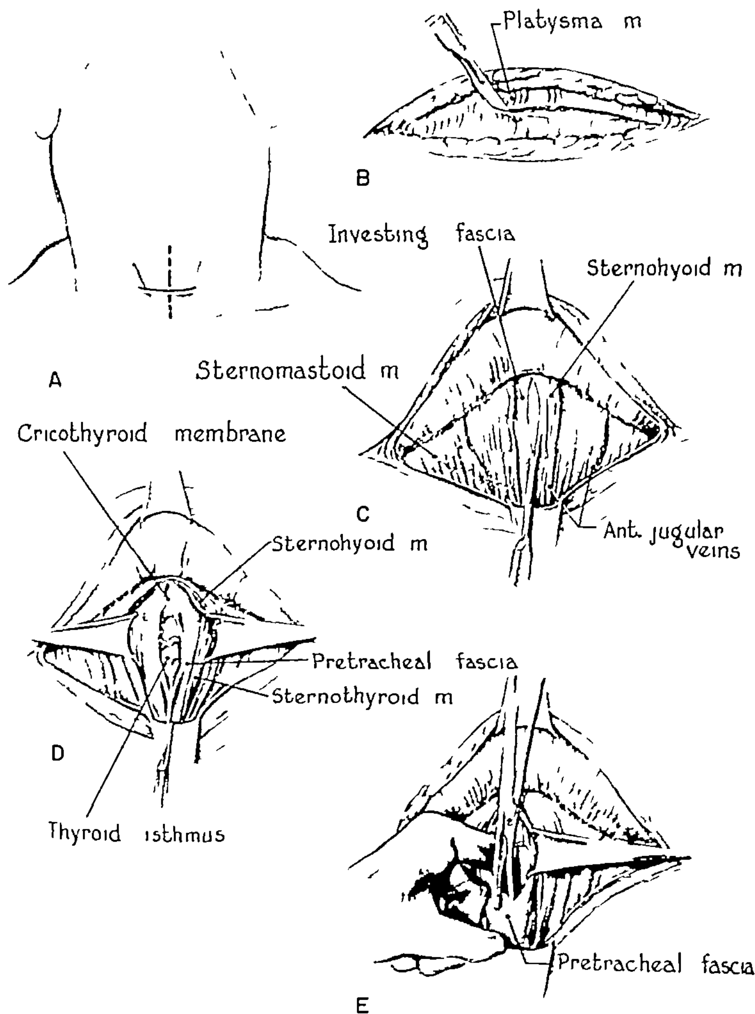
Plate 13 (I) demonstrates the presence of a few fibrous adhesions attached to the inferior border of the arching subclavian artery These are occasionally situated about the vasa vasorum If they are injured, troublesome extravasation of blood will occur between the muscular and adventitial layers of the subclavian artery This is best avoided by severing the fibrous adhesions some distance from the vessel.

The layers of the deep cervical fascia—the so-called "fat pad," which, incidentally harbors Virchow's lymph node on the right side—contain many fine blood vessels. These are disrupted in this procedure, and care must be taken to avoid oozing which will stain the surrounding structures, making identification difficult. They can readily be electrocoagulated, or if such a unit is not available, ligation may be necessary

Irrigation of the operative area with warm saline, gentle suctioning, and the use of wet cotton strips or "paddies" used for sponging, quite satisfactorily *serve the purpose of maintaining the normal appear*ance of tissues. When sectioning the scalenus anticus muscle, the oozing encountered can be minimized in this fashion, thus enabling the surgeon to identify precisely the structure he is about to divide

In closing the wound, in addition to the readily recognized necessity for closing the deep cervical fascia over the "fat pad" to avoid a troublesome postoperative "lump" beneath the incision, two considerations are noteworthy They are, first, that a deeply placed suture near the clavicle can perforate the subclavian vein, and second, that an attempt should be made to avoid a resultant ugly scar espe*cially in a female patient.* The wound should, of course, be closed in layers, preferably with interrupted 0000 silk sutures as Doctor Madden suggests. This should include a subcuticular layer placed deeply enough to be well covered by the thin skin in this area.

A very careful skin closure with 000000 arterial silk" and an atraumatic needle will afford accurate approximation of the wound edges and prevent an unsightly scar


Platysma m
B
A
Investing fascia
Sternohyoid m
Sternomastoid m
Cricothyroid membrane
C
Ant. jugular veins
Sternohyoid m
Pretracheal fascia
Sternothyroid m
D
Thyroid isthmus
Pretracheal fascia
E

TRACHEOSTOMY

A tracheostomy may be performed either electively or as an emergency operation. Frequently it is done as an emergency procedure and, unfortunately it is oftentimes performed too late. A good dictum to follow is that if the necessity for the performance of a tracheostomy is seriously questioned, it is usually a good indication for the operation The technic for an elective tracheostomy is illustrated.

A. The two types of incision employed, the transverse and longitudinal, are indicated. The transverse incision is preferred.

B. The incision is deepened through the subcutaneous tissue plane and its continuation through the fibers of the underlying platysma muscle is shown.

C. The upper and lower flaps of skin, subcutaneous fat and platysma muscle are retracted and with a scalpel, the anterior or investing layer of the deep cervical fascia is incised in the midline.

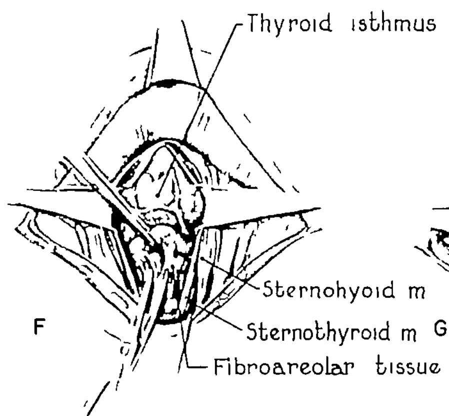
D The sternohyoid muscles are retracted, and the underlying anterior borders of the sternothyroid muscles may be seen. An incision is made through the middle or pretracheal fascia layer of the deep cervical fascia to expose the isthmus of the thyroid gland.

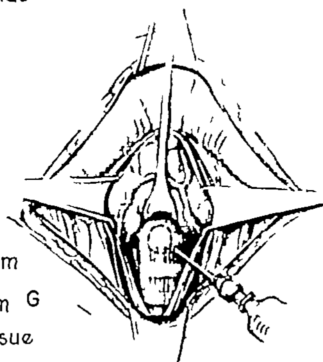
E. The left finger of the surgeon is inserted downward beneath the pretracheal fascia and the incision in this fascia is extended caudad by scissor dissection.

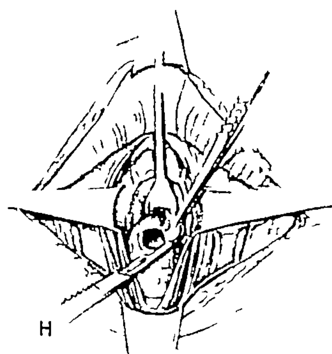
Discussion—Dr. Edgar L. Frazell. The choice of the skin incision for tracheostomy is usually dictated by the circumstances of the individual case When performed electively it is usually done as an integral part of some other operative procedure about the head and neck region

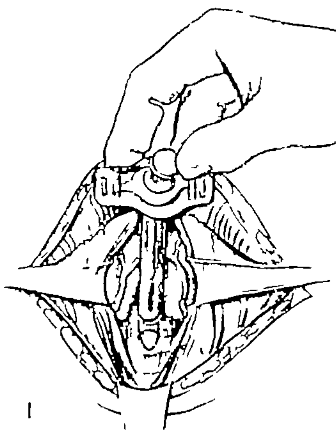
The type of incision must then conform to the necessities of the primary operation. As an emergency measure tracheostomy is both dramatic and life saving. Rapid exposure of the trachea with minimal dissection of skin flaps is imperative in such cases. I find this is facilitated by the use of the vertical midline incision as it minimizes blood loss from the distended veins in the area. Furthermore, the incision through subcutaneous tissue and fascia corresponds to the natural cleavage plane between the pretracheal muscles. Additional exposure is obtained by extension of the incision in either direction to allow for variations in the position of the thyroid isthmus. The latter structure may be retracted superiorly or inferiorly or rapidly divided between clamps to expose the second or third tracheal ring.

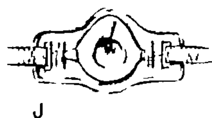
*The important objective in an emergency tracheos*tomy is to establish an artificial airway in the shortest possible time. Simple incision of two or more tracheal cartilages is usually sufficient for introduction of the canula, though some surgeons prefer excision of a window The latter technic tends to delay spontaneous closure of the fistula after the emergency is past. Suture of the wound about the tracheostomy may lead to troublesome subcutaneous emphysema in some cases and cellulitis in others.


Thyroid isthmus
Sternohyoid m
Sternothyroid m
Fibroareolar tissue
F


G


H


I


J

Wabnitz

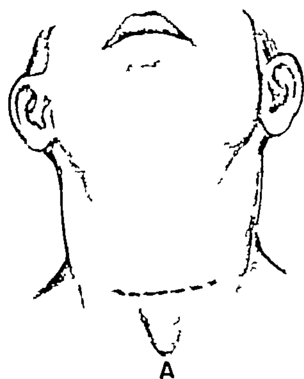
F The incision in the pretracheal fascia layer is completed, and a portion of the trachea is exposed. The inferior border of the isthmus of the thyroid gland is grasped in anatomic forceps and its attachment to the anterior surface of the proximal portion of the trachea is freed by scissor dissection.

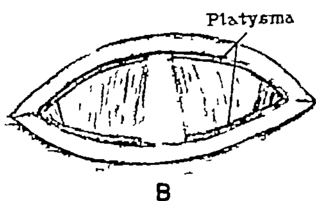
G The isthmus of the thyroid gland is retracted upward, and the oval segment of the trachea to be incised is indicated in dotted outline. A segment of the third and frequently the fourth tracheal rings is included in this excision. Entrance into the trachea above this level is avoided to prevent the subsequent occurrence of laryngeal stenosis. Immediately prior to opening into the trachea, 8 to 10 minims of cocaine (10 per cent) is injected into its lumen as depicted. This maneuver originally suggested by Sir St Clair Thomson, lessens the cough as the tracheal lumen is entered.

H, I. The severance of the remaining attachment of the oval segment of the anterior portion of the trachea is being completed (H) prior to the insertion of the tracheostomy tube (I). In the adult, the No 5 and No. 6 tubes are the two sizes most commonly employed. In the infant child and adolescent, tubes ranging in size from No 0 to No 4 may be used.

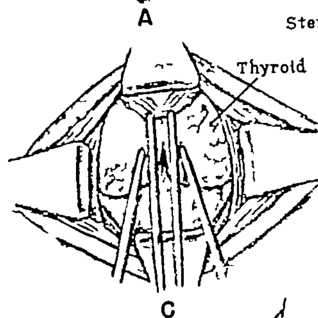
J The tracheostomy tube is inserted and the obturator removed to complete the operation. One or two skin sutures to approximate loosely the skin margins may be inserted. This type of wound is always potentially infected and accordingly a layer or tight closure of the incision is avoided. In some instances no sutures are used, the wound being covered by a moistened sterile split piece of gauze.

Plate 16

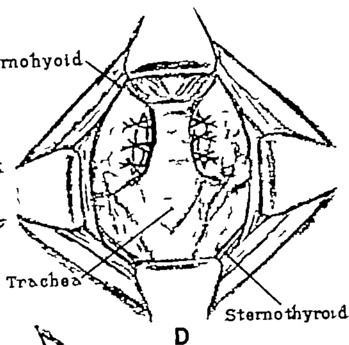

A



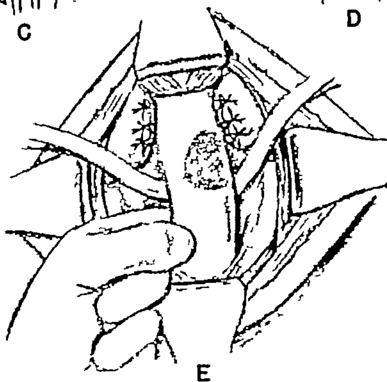
B



C



D


E

EXCISION OF CYLINDROMA OF THE TRACHEA

The patient a 60-year-old white man, was admitted to the hospital because of progressively worsening inspiratory dyspnea. Three years previously a diagnosis of chronic lymphatic leukemia was established and the response of the patient to the treatment prescribed was satisfactory

The present symptoms were at first thought to be due to compression of the trachea by enlarged mediastinal lymph nodes Accordingly a course of nitrogen mustard therapy was prescribed without benefit. A bronchoscopy was done, and no gross abnormalities were detected. A bronchogram was then performed, and a constant filling defect in the upper third of the trachea was demonstrated. A repeat bronchoscopy was done, and on insertion of the bronchoscope no gross abnormalities were observed on its withdrawal, however the smooth *outline of the tumor which was attached to the left posterolateral wall of the trachea was* readily visible

It is now two years since the removal of the tumor (cylindroma) and the patient is completely without symptoms

A, B. The transverse "collar" incision depicted (A) is deepened through the platysma muscle layer and the sternohyoid muscle to either side of the midline is shown (B)

C, D The isthmus of the thyroid gland is serially clamped and severed (C) to expose the trachea (D) The clamps on the isthmus are replaced with suture ligatures of 000 silk (D)

E. A long segment of the trachea is mobilized and encircled by a cotton tape The location of the tumor within the lumen of the trachea is indicated in stippled outline.

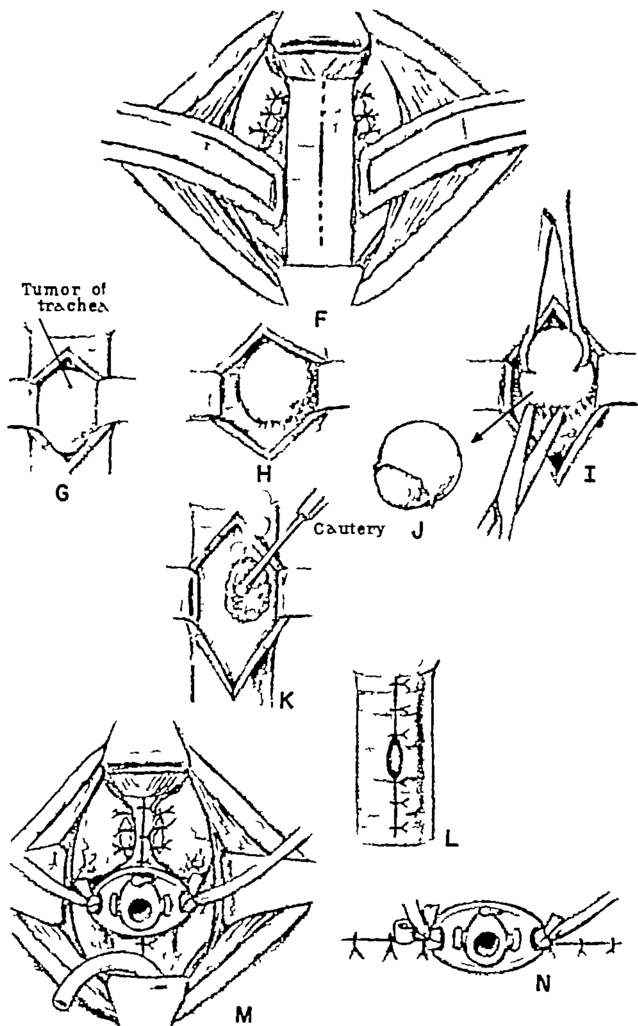
DISCUSSION—DR. JOHN L. POOL. Tumors of the trachea of all sorts are quite rare. The so-called bronchial adenomas are the most common, and of these the carcinoid type is found four or five times as frequently as the cylindroma. The usual symptoms, as in Dr Madden's patient, are cough and strangulation The diagnosis should be suspected in such patients when the chest roentgenogram is negative. Palpation of the neck is unrewarding unless nodal metastasis has occurred which is unusual. Mirror laryngoscopy will only reveal a vocal cord paralysis in those instances where the tumor has extended into the tracheoesophageal groove.

Sometimes mirror laryngoscopy will reveal the superior face of an upper tracheal adenoma, but the best *evaluation of the size and exact location* of these tracheal tumors is by radiographic technique, especially Bucky and tomographic films in two planes. Bronchoscopy will allow visualization, and biopsy may be attempted. When located on the posterior tracheal wall esophagram and esophagoscopy should be included in the presurgical evaluation, since some growths transgress the party wall without involving the recurrent laryngeal nerves. Diagnosis by sputum cell study has been unrewarding.

Recent studies of adenomatous tumors of the trachea and bronchi, such as that by Dr Goodner (1) suggest the probability that these lesions are in reality malignant though their rate of growth is slow and evidence of metastasis may be delayed many years. Wider excision than simple enucleation is, therefore, indicated.

Planning the approach that is most direct to the involved portion of trachea is aided by roentgenographic localization A cervical approach, as illustrated is certainly simpler than thoracotomy and can be extended if necessary by median sternotomy Lesions in the distal third of the trachea are best approached by a right posterolateral thoracotomy In any case, anesthesia by endotracheal tube is essential, and it is well to have a sterile *duplicate set of anesthesia tubing* available in case control of respiration distal to the tumor becomes necessary In this case the sterile tube can be introduced into the distal trachea by the surgeon and the connection to the anesthesia apparatus handed off the field

The careful exposure achieved by Dr Madden (C, D E) is essential prior to actually approaching the tumor The recurrent laryngeal nerves should be dissected out in their entire course to avoid trauma, and the esophagotracheal wall dis-


F
Tumor of trachea
G
H
J
I
Cautery
K
L
M
N

F Ribbon retractors are inserted over protective moist gauze pads into the depths of the wound on either side of the trachea. The incision in the trachea and its subsequent extension are indicated by the solid and broken lines, respectively

G, H. The incised margins of the trachea are retracted to show the tumor (G) which is better seen after enlarging the opening (H) The broken line (H) depicts the plane of dissection for the detachment of the tumor from the left posterolateral wall of the trachea.

I, J The encapsulated tumor is held in a Babcock clamp and as upward traction is maintained, it is freed by scissor dissection (I) and removed (J) The irregular circumscribed margin of its capsule is visible (J)

K. The site of attachment of the tumor to the wall of the trachea posteriorly is fulgurated both for its hemostatic and possible cancericidal effects.

L. The tracheal incision is partially closed, using interrupted sutures of 000 silk

M. A tracheostomy tube (No 6) is inserted through the center opening, and a drain is placed in the dependent portion of the wound.

N The closure of the incision about the tube and drain completes the operation.

DISCUSSION—DR. POOL (cont)

sected free, as illustrated, unless there is evidence of esophageal invasion requiring resection of the invaded portion of that organ.

Dr Madden illustrates admirably the need for wide exposure within the trachea. I do not, however believe in grasping these tumors, fearing cell dissemination but prefer traction sutures through the adjacent tracheal wall. Also, it is wise because of the malignant potential of cylindromas to take a 1 cm. cuff of normal tissue beyond the visible growth and to remove the full thickness of the tracheal wall. In my experience this is best repaired by a wire reinforced dermal graft, after the method of Gebauer (2)

A tracheostomy is always essential to reduce pressure on the suture line, but I do not recommend drains adjacent to the tracheostomy because of the inevitable infection. Such an operation as the one illustrated probably does not require drainage, but if for reasons of "dead space" or continued ooze, drainage is necessary it is more safely done through a lateral stab wound and into areas sealed off from the trachea. An operative or postoperative complication that may occur is pneumothorax. The mechanism is by suction of air from the open neck wound into the retrosternal space in a patient whose airway is partially obstructed Rupture of the mediastinal pleura on one or both sides then occurs and would be apparent during or immediately after the procedure, as described by Bowden and Schweizer (3) Careful follow-up of these patients is mandatory because of the danger of recurrence.

REFERENCES

1 Goodner J T Berg, J W and Watson W L. The nonbenign nature of bronchial carcinoids and cylindromas. Cancer 14 539 1961
2. Gebauer Paul W Bronchial resection and anastomosis, J Thoracic Surg 26 241 1953
3 Bowden, Lemuel, and Schweizer Olga. Pneumothorax and mediastinal emphysema complicating neck surgery Surg., Gynec. & Obst., 96 81 1950.

DIAPHRAGM

INT MAMMARY VESSELS

PERICARDIUM

SUP VENA CAVA

PHRENIC N

VAGUS N

TRACHEA

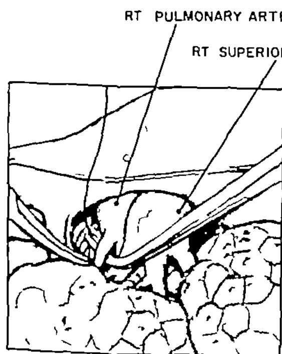
AZYGOS V

Upper lobe

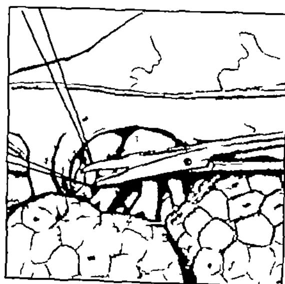
Middle lobe

A

B



C



D

PULMONARY LOBECTOMY RIGHT UPPER LOBE

A. The patient is placed in the direct left lateral prone position, and the right postero-lateral thoracotomy incision overlying the fifth rib is indicated

B. The right pleural cavity is entered, and the related structures are depicted. The left lung is displaced posteriorly and the pleura overlying the hilar structures anteriorly is severed (broken line) by scissor dissection.

C, D The pulmonary artery and superior pulmonary vein are exposed, and the mobilized apical branch of the pulmonary artery is being encircled by a silk (00) ligature (C) This artery doubly ligated in continuity is being severed between the ligatures (D)

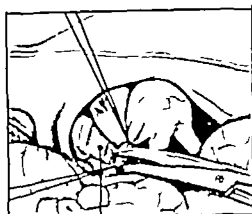
DISCUSSION—DR. JULIAN JOHNSON The technic of upper lobectomy described differs in no major way from that which I have utilized for many years. I will, however point out minor variations in technic simply as a matter of interest to the reader

The lateral position with a posterolateral incision is preferred for upper lobe lobectomy since it is felt that this puts the operator in the best over-all position to approach the hilum of the lobe or lung from all directions. However either the face-down position or the supine position can be used for right upper lobe resection. The face-down position is indicated in the event that an upper lobe resection is to be carried out in the presence of cavitary disease of the upper lobe when there is still an appreciable amount of secretion present' this places the anesthetist in a more favorable position to keep the other lobes and the other lung clear of secretions. Fortunately with our present methods of preoperative preparation, the surgeon these days seldom finds himself in the position of having to use this position. While the anterior approach is perfectly feasible, I have not used it in a good many years, it being my thought that it leaves a bit less room for error in the performance of the lobectomy and places the surgeon in a more difficult position if he has inadvertently torn a major vessel or finds a good many adhesions present at the time of operation.

The resection of a rib during thoractomy has been largely abandoned by me, except in those instances where there is reason to believe that there is an obliteration of the pleural space, such as when an extrapleural pneumonectomy for tuberculous empyema is being performed. I normally use the fourth interspace incision for the right upper lobe, although the fifth is acceptable. If the fifth intercostal incision is made, it is preferable to cut the fifth rib posteriorly to gain adequate exposure. When the operation is being carried out on a young person, the intercostal incision usually gives satisfactory exposure, but when operating upon an older person, it is preferable to cut at least one rib posteriorly Whether a rib is resected or not is probably of very little importance. I have thought if the rib is not resected it has allowed more rapid closure of the chest and also gives a nicer appearance on the postoperative roentgenograms.

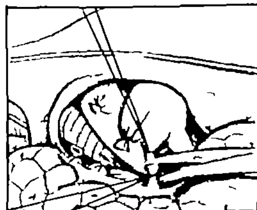
The Burford modification of the Finochietto rib spreader or some similar modification has received wide acceptance, as opposed to the double rib spreaders illustrated

Although there is considerable variation, the first branch of the right pulmonary artery is usually the apical anterior branch, which comes off as one artery and then bifurcates into the apical and the anterior branches shortly thereafter If the artery referred to as the apical branch of the pulmonary artery in C is supposed to represent the joint trunk of the apical anterior artery as suggested by its bifurcation in D it is unusually small in this particular patient and represents a smaller portion of the right pulmonary artery blood flow than one usually sees. It has been my custom in



E

BRONCHUS



F

RT UPPER LOBE

RT MIDDLE LOBE

MAJOR INTERLOBAR FISSURE

G

RT LOWER LOBE

INCOMPLETE FISSURE BETWEEN UPPER AND MIDDLE LOBES

POST SEGMENTAL ARTERY

SUP SEG A LOWER LOBE

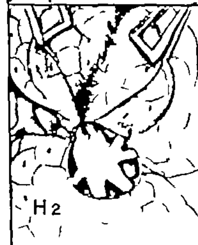
BASAL SEG ARTERIES

ARTERY TO MIDDLE LOBE AND BRANCHES

H



H_1



H_2

E, F The apical tributary of the superior pulmonary vein is doubly ligated (00 silk) in continuity and transected with scissors between the ligatures (E) The anterior tributary is treated in like manner (F)

G. The middle and lower lobes are retracted in opposite directions, and the visceral pleura lining the major interlobal fissure is cut (broken line) with scissors.

H. A segment of the pulmonary artery and its branches to the upper middle and lower lobes are visible The posterior arterial branch is being mobilized by scissor dissection

H_1 The posterior artery is doubly ligated (00 silk) in continuity and severed (broken line) between the ligatures

H_2 In some patients two posterior arterial branches may be present, as indicated.

DISCUSSION—DR. JOHNSON (cont.)

the division of most of these arteries and veins in this area to back up the proximal ligature with a suture ligature in juxtaposition to it.

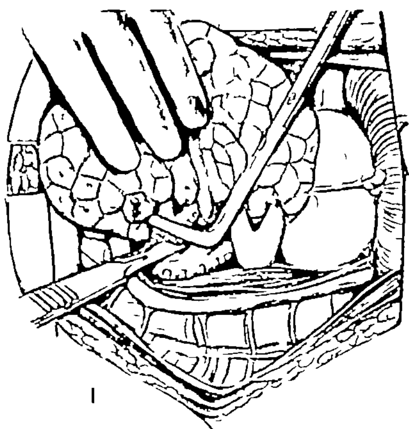
In the division of the venous supply to the right upper lobe I have frequently found it possible to identify the tributaries to the superior pulmonary vein coming from the middle lobe and then ligating the remaining portion of the superior pulmonary vein just distal to the point where the middle lobe tributary joins it. It may be necessary to put the distal ligatures on the branches, but the proximal ligature can frequently be placed around the remaining vein with a suture ligature in juxtaposition to it.

E and F show only two branch veins coming from the upper lobe, the apical and anterior tributaries. Much more commonly there is a vein coming from the posterior segment of the upper lobe. Also the apical anterior vein frequently joins to form one tributary and there is another tributary referred to by some as the inferior vein. Considerable care is indicated in placing the ligature around the distal portion of the posterior segmental vein, since it is in very close proximity to the pulmonary artery

If after the division of the major vessels on the anterior aspect of the hilum of the upper lobe, one has a situation where the major fissure is tightly fused, the upper lobe can be displaced posteriorly and downward and the upper lobe bronchus exposed in that manner and divided, rather than approached from the rear as shown. As the distal portion of the severed bronchus is then gently retracted, the fissure between the posterior part of the upper and lower lobes can be divided. The posterior segmental artery will then come into view and can be divided, and the minor fissure can be divided, separating the upper from the middle lobe.

Separation of the upper from the middle lobe is not illustrated in this series. This fissure is seldom complete and almost always has to be divided by sharp and blunt dissection, as illustrated in the section on lower and middle lobe lobectomy In this instance, however the upper lobe would be collapsed and the middle lobe inflated. Following the separation of this fissure, I feel that it is important to stop all of the air leaks if possible—certainly at least the major ones. The technic which I have found very useful is to clamp the area on the surface of the fissure that is leaking with a Babcock clamp and place a catgut tie behind it.

In the division of the bronchus it has been my custom to use two Sarot bronchus clamps and cut between them. The Sarot clamp is a noncrushing clamp. Silk sutures are placed behind the clamp with a short straight needle, and the clamp is removed before the ligatures are tied over the end of the bronchus. The bronchial stump can then be buried under the pleural flap containing the azygous vein.



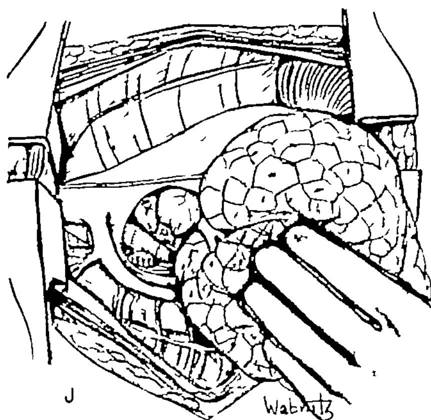
I



I_1



I_2



J

I. The branch bronchus to the right upper lobe, occluded by a clamp (Sarot) distally is being severed proximally with a scalpel.

I_1 I_2. The insets show an extended dissection of the upper lobe bronchus to expose its segmental branches (I_1) and the partially severed bronchus being occluded with sutures (000 silk) as its transection is continued (I_2)

J The operative field on completion of the right upper lobe lobectomy is seen in relation to the surrounding structures. Before closure of the wound two catheters are inserted. One (18 F) is placed anteriorly as an air vent, and the other (24 F Foley) posteriorly for the drainage of fluid. This is shown in the illustrated technic for re moval of the lower lobe of the left lung.

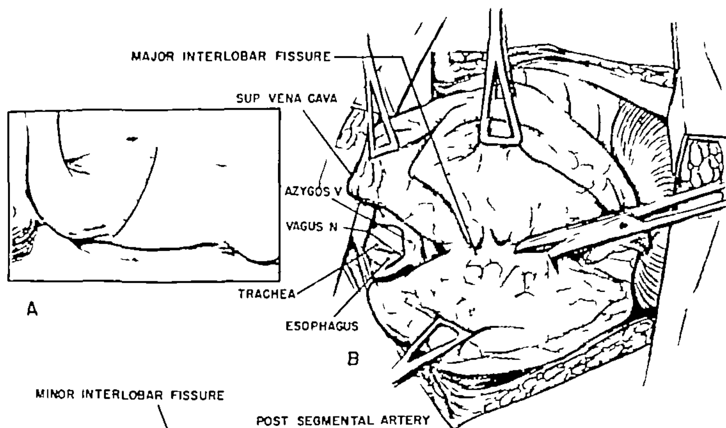
Discussion—Dr. Brian Blades. Although some surgeons still employ an anterior approach for upper lobe lobectomy the posterolateral approach has many advantages. Whether one resects a portion of the fifth rib or employs an intercostal incision between the fifth and sixth ribs will depend upon the age of the patient and general habitus. In older patients it is usually better to do a subperiosteal excision of the portion of the rib, since with the intercostal incision adequate exposure often results in multiple fractured ribs.

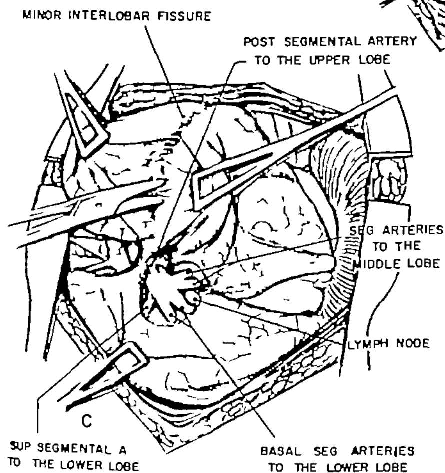
In C the apical branch of the pulmonary artery to the upper lobe is shown, but it would be an advantage if the anterior branch was labeled, since it is often possible to ligate the artery proximal to the division of anterior and apical branches.

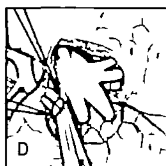
If an upper lobe lobectomy is being performed for carcinoma, it is of great advantage to ligate and divide the major azygous vein. This insures better exposure of the mediastinum and any lymph nodes that may be involved.

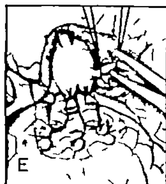
In patients with suppurative disease in whom secretions are troublesome during the performance of the lobectomy it is easy and possible to divide the bronchus first, approaching it from the posterior aspect.

If possible, it is desirable to separate the incomplete fissures between the upper and middle lobes, and often between the upper lobe and the superior division of the lower lobe after the hilar dissection has been completed. By doing so, the amount of bleeding from the incomplete fissure surfaces is minimized.


MAJOR INTERLOBAR FISSURE
SUP VENA CAVA
AZYGOS V
VAGUS N
TRACHEA
ESOPHAGUS
A
B


MINOR INTERLOBAR FISSURE
POST SEGMENTAL ARTERY
TO THE UPPER LOBE
SEG ARTERIES
TO THE
MIDDLE LOBE
LYMPH NODE
C
SUP SEGMENTAL A
TO THE LOWER LOBE
BASAL SEG ARTERIES
TO THE LOWER LOBE


D


E

PULMONARY LOBECTOMY COMBINED RIGHT *MIDDLE AND LOWER LOBES*

A. The patient is placed in the direct right lateral prone position, and the thoracotomy incision is outlined and cross-hatched to *facilitate later closure.*

B. Clamps (Duval) are applied to the right lung, and as traction is maintained, the visceral pleura overlying the major inter lobar fissure is severed by scissor dissection

C. The major fissure is opened, and the arterial branches to the lobes of the right lung are indicated. The incomplete fissure between the upper and middle lobes is being dissected with scissors.

D The artery to the superior segment of the lower lobe is doubly ligated (000 silk) in continuity and severed (broken line)

E. Similarly the arteries to the basal segments of the lower lobe and to the middle lobe are ligated and severed. The arterial branch to the posterior segment of the upper lobe re mains intact.

DISCUSSION—SIR RUSSELL BROCK (cont.)

is formed by fascia covering the aortic arch the posterior wall is the trachea, and the anterior is formed by the superior vena cava.

In the illustrations the hilar areolar space is opened to secure the upper lobe arteries as a first step. This is unnecessary, undesirable, and frequently impossible. It is preferable to incise the pericardium along the line of the displaced phrenic nerve. If the veins are to be secured this can now be done. In this event the phrenic nerve and vessels *should be freed down to the diaphragm* ligated, and divided and the pericardial incision continued to just below the inferior pulmonary vein.

It is the custom in standard textbooks of anatomy to describe the veins as joining the left atrium separately; the illustrations show them being individually secured and ligated. This again is unnecessary and undesirable. In the living subject it will be found that a common pulmonary vein always exists, or at any rate that it is possible to encircle a portion of the atrium where the veins join it, so that what is virtually a common trunk of entry is displayed. This can be defined by a very little dissection above and posteriorly after the mesentery of the inferior vein has been divided. The finger or an instrument slips all the way round except for this one site above and behind. A single heavy ligature is then tied around this common trunk. Working from inside the pericardium and without disturbing the hilar areolar tissue, the pericardium can be gently and easily pushed laterally to expose the superior and inferior veins joining to form the common vein. Each is encircled by a transfixion ligature. In all of these large vessels a transfixion stitch should be used to guard against slipping but should be supported by a proximal ligature.

The pericardial incision is now continued upward, where it will be found that a small recess extends in front of the right pulmonary artery and lateral to the superior vena cava. This recess should be completely opened, and the operation field then joins the previous clearance of the right tracheobronchial fossa. It is now a simple matter to free the lower part of the superior vena cava and to rotate it medially making use of the stump of the vena azygos left long for this purpose. The clearance of the lymph nodes can be carried a stage farther and the pulmonary artery is now *widely exposed as it lies partly within the serous pericardium and partly outside it* and emerging from under cover of the superior vena cava. It is now encircled *well within the mediastinum*, behind the vena cava and medial to the hilar "box." A long length of artery is available for double ligation, the first ligature encircling the vessel and the more lateral one first transfixing it. The part of the artery adjacent to the lung is either ligated or secured with a clamp before being divided. If growth extends along or around the main right pulmonary artery resection may be impossible without this maneuver which allows dissection so deep within the mediastinum. In very difficult cases it may be necessary to leave the division of the artery as the last step of removal of the lung so that meticulous freeing from growth is possible just as may be needed in similar circumstances with the division of the veins or of the main bronchus.

Once the artery is divided, lymph nodes are displayed lying in front of the lower end of the trachea, joining laterally and above with those in *the right tracheobronchial fossa and medially* with those within the concavity of the aortic arch. A deliberate clearance in continuity can be made. At this stage in a *right* radical pneumonectomy the *left* recurrent laryngeal nerve is displayed as part of a good operation.

Attention now should turn to the ligamentum latum previously partly opened when the phrenic nerve and vessels were ligated above the diaphragm. This fold of pleura should be ligated and cut from the diaphragm, and an incision should be made along its posterior surface to join the original pleural incision on the back of the hilum. The ligamentum latum is then carefully dissected from its medial relation, the esophagus, any vessels are secured, and the lymph nodes are meticulously excised with it. There is always a large well-defined "sentinel" node in the highest part of the ligament immediately below the inferior pulmonary vein. Once this has been swept from the adjacent pericardium, this structure can be divided horizontally below the inferior pulmonary vein and then vertically upward until the inferior tracheobronchial fossa is opened. If the veins have not been earlier secured, they may now be taken and divided. In this way the inferior tracheobronchial compartment is widely displayed for clearance of its lymph node group and for confirming that the bronchus clamp is placed at the very origin of the bronchus immediately below the carina.

A distal clamp is then applied, the bronchus is divided between the two clamps, and the lung is removed.

There are many ways of suturing the bronchus. A method that has proved very successful in my practice has been the use of interrupted stainless steel sutures passed as a figure of 8 around the clamp, which is removed before the individual sutures are tied.

It is preferable, but not essential, to cover the cut end of the bronchus. If the vagus nerve was preserved and displaced backward, it will be found that a fascial fold passes like a mesentery from it to the lateral surface of the esophagus. Two fine *mattress sutures are passed through this fold* and pick up fascia on the front of the bronchus stump; when tied, they cover the stump with the fascia, the vagus nerve being displaced harmlessly in front of the bronchus. Sometimes a long piece of parapericardial fat may be fashioned or mobilized from the anterior pericardiophrenic angle so as to be sutured over the bronchus stump.

F Upon completion of the ligation and severance of the arterial blood supply to the middle and lower lobes, the right lung is manually retracted upward and the inferior pulmonary ligament is doubly clamped and severed (broken line)

G, H. The anterior layer of the inferior pulmonary ligament is cut in a cephalad direction (G) to expose the inferior and superior pulmonary veins (H) The vein draining the middle lobe, a tributary of the superior pulmonary vein, is first doubly ligated (000 silk) in continuity and then a transfixion suture ligature of 000 silk is inserted in juxtaposition to the proximal ligature (H)

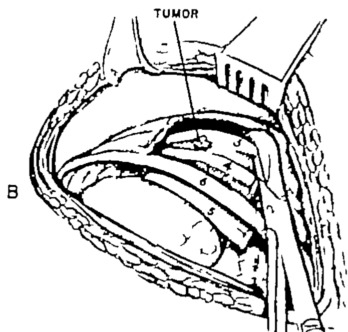
I, J The middle lobe vein is severed between the transfixion suture ligature and the distal ligature The remaining intact tributaries of the superior pulmonary vein drain the upper lobe.

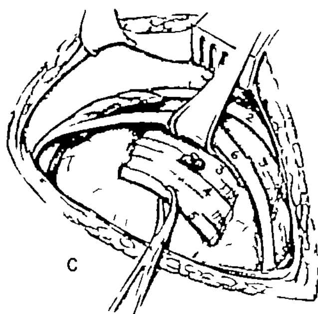
DISCUSSION—DR. JULIAN JOHNSON The lateral position with the usual posterolateral approach is preferred for resection of the right middle and lower lobes. On the other hand, if the patient is being operated upon for suppurative disease or if there is a tumor present with suppuration behind it, it may be wise to use the face-down position. I seldom find this necessary at the present time with the modern means of preoperative preparation, but occasionally particularly in the presence of bronchial stenosis, it is difficult to get the patient clear of secretions and the face-down position is advisable. In the lateral approach the incision is made in the fifth or sixth intercostal space. In a person of middle age or older the upper rib is divided posteriorly to give adequate exposure.

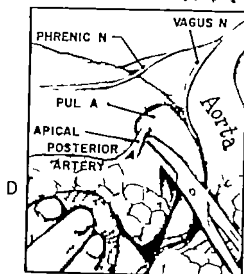
The Duval clamps shown in B have been widely used, but I prefer not to apply even this relatively atraumatic clamp to the lobe that is not to be removed, but rather to hold the lobe aside with a sponge stick. In the division of the arterial supply to the lower and middle lobes, it is sometimes possible to divide the pulmonary artery as one trunk right below the artery to the posterior segment of the upper lobe rather than as five separate branches as shown. Most often, even when a single ligature can be placed proximally multiple ligatures will be placed distally in order to get an adequate cuff beyond the proximal ligature. It is my custom to back up the proximal ligature with a suture ligature in juxtaposition to it in all of the arterial branches in a manner similar to that shown in H for the pulmonary vein.

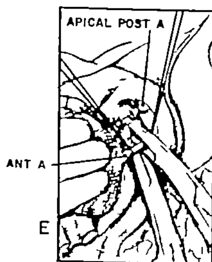
It is my custom to divide the inferior pulmonary ligament (F) up to the inferior pulmonary vein both in front and back at the beginning of the operation as a precautionary measure. If any of the great vessels at the hilum of the lung should be inadvertently torn this places the surgeon in

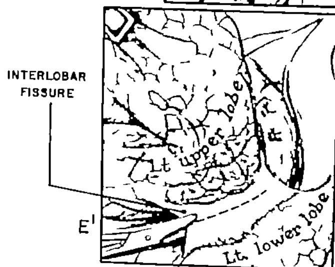

A


TUMOR
B


C


VAGUS N
PHRENIC N
PUL A
APICAL
POSTERIOR
ARTERY
Aorta
D


APICAL POST A
ANT A
E


INTERLOBAR
FISSURE
Lt upper lobe
Lt. lower lobe
E'

PULMONARY LOBECTOMY LEFT UPPER LOBE

The patient, an 80-year-old white man whose apparent good general condition belied his age, was admitted to the hospital with the chief complaint of constant pain in the left axillary region of two months duration. The pain radiated downward along the lateral chest wall was worse at night, and of progressively increasing severity During the same period there was an associated weight loss of 25 pounds Also recurrent episodes of hemoptysis, never severe occurred and persisted. A box of cigars was smoked weekly

Bronchoscopy was essentially normal. A roentgenogram of the chest showed a circumscribed shadow of increased density located peripherally in the left upper lobe, which merged indistinguishably with the adjacent pleura Because of the constant chest pain and roentgenographic findings, infiltration of the overlying pleura and chest wall was suspected This was confirmed at operation as shown Death due to metastatic disease occurred nine months after operation

A. The patient is placed in the direct right lateral prone position, and the posterolateral thoracotomy incision overlying the fifth interspace is outlined and crosshatched to facilitate later closure.

B, C. The incision is deepened into the pleural cavity and a segment of the costal cage (second, third, and fourth ribs) infiltrated by the tumor is resected as a part of the surgical specimen.

D The mobilized segment of the costal cage is covered with a moist gauze sponge, and as manual traction downward is maintained, the areolar tissue attachments between the upper lobe and the pulmonary artery are freed by scissor dissection. The apical-posterior branch and its bifurcation just prior to its entrance into the lung parenchyma are visible

E. The apical-posterior artery is doubly ligated (00 silk) and transected. An anterior branch, doubly ligated (00 silk) in continuity is being severed with scissors between the ligatures.

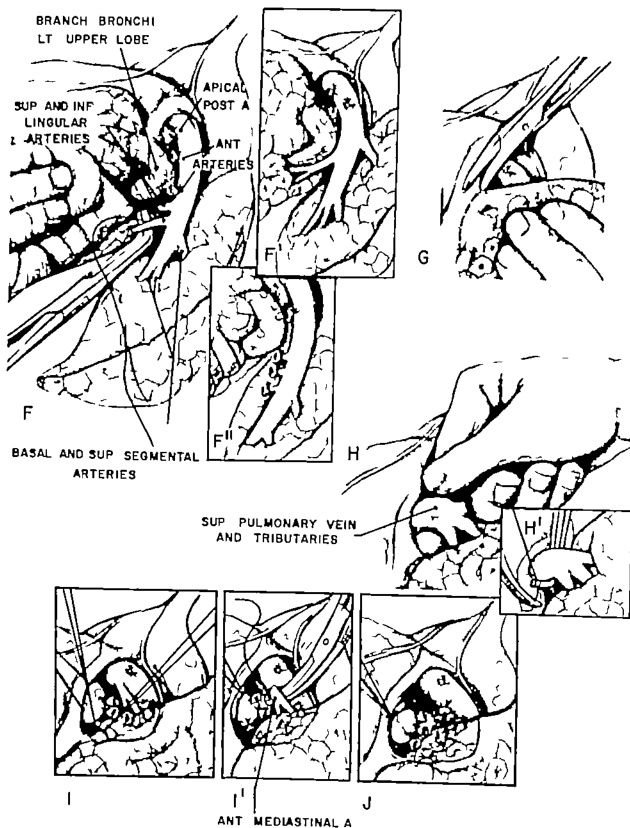
E' The upper lobe is retracted upward and medialward to show the interlobar visceral pleura being severed (broken line) for the further exposure of the pulmonary artery and its branches

DISCUSSION—DR. CHARLES K KIRBY Removal of the left upper lobe is usually carried out for the purpose of excising a tumor that is located peripherally Ten years ago resection of the left upper lobe was performed with relative frequency for inflammatory lesions, tuberculous and nontuberculous Lobectomy for inflammatory lesions has become much less common in my experience, and this has also been true of many other surgeons with whom I have discussed this subject.

When a bronchogenic carcinoma has invaded the chest wall, as in the patient presented, resection is often warranted for palliative purposes and for the purpose of attempting to obtain a prolonged survival. The long-term results are not as favorable, in my experience, when the pleura has been invaded by tumor cells and resection of a portion of the chest wall is necessary

It is usually desirable to carry the skin incision further anteriorly than is depicted in A By extending the skin incision as far anteriorly as the nipple line, it is often possible to open the rib spreader to a somewhat greater extent without risking fracture of a rib Rib fractures that occur as a complication of opening the rib spreader appear to increase the postoperative pain to a considerable extent in many patients.

One of the problems complicating left upper lobectomy in a significant percentage of patients is the presence of adhesions between the visceral and parietal pleura. Before beginning the dissection of the hilum in such patients, it is necessary to deal with these adhesions first, which may be an exceedingly difficult problem Not uncommonly the problem of freeing adhesions that bind the apex of the upper lobe to the apex of the pleural cavity is considerably more difficult from the technical standpoint than the problems encountered in dealing with the hilar structures. When possible, it is advisable to divide the adhesions intrapleurally carrying the dissection a little closer to the upper lobe than to the chest wall. If the adhesions are vascular this provides some tissue on the chest wall side that can be clamped and ligated, which is the simplest method of dealing with blood vessels which accompany adhesions. If the adhesions are very short, however or if there is actual symphysis between the parietal and visceral pleura, the dissection may have to be carried out extrapleurally Control of bleeding, particularly at the apex of the chest, is considerably more difficult when an extrapleural dissection is necessary During such a dissection the greatest risk is that of injuring the axillary vein. This is a very real hazard, and the most important factor in avoiding it is certain knowledge of the actual location of the axillary vein By careful palpation of the axillary artery and the first rib, it is possible to localize the


BRANCH BRONCHI
LT UPPER LOBE
SUP AND INF
LINGULAR
ARTERIES
APICAL
POST A
ANT
ARTERIES
F'
G
F
F''
BASAL AND SUP SEGMENTAL
ARTERIES
H
SUP PULMONARY VEIN
AND TRIBUTARIES
H'
I
I'
J
ANT MEDIASTINAL A

F F' The interlobar fissure *is opened* and the relation of the pulmonary artery and its branches to the lobes of the lung and the relation of the stem bronchi to the left upper lobe are visible In this patient there were two anterior branches (both ligated and severed) The lingular arteries arose separately from the pulmonary artery rather than from a common trunk (F') which is more frequently found The artery to the inferior segment of the lingula is being encircled with a ligature of 000 silk. The more common arrangement of the arterial branches to the left upper and lower lobes is shown in F' In these two specimens (F F') *there is a slight variation in the relation* of the arterial branch to the superior segment of the lower lobe and the arterial supply to the lingula

F" The ligation and severance of the arterial branches to the left upper lobe is completed.

G The upper lobe is manually retracted posteriorly and the anterior mediastinal pleura is severed (broken line) by scissor dissection for the exposure of the superior pulmonary vein

H. The superior pulmonary vein is mobilized *by both clamp and digital dissection. The* use of the index finger for dissection is an efficient, safe, and highly recommended *method that minimizes* the danger of injury to the vein and resulting hemorrhage.

H' When its mobilization is completed, the superior pulmonary vein is encircled with a ligature of 00 silk, which is not immediately tied

I. *Two of the tributaries of the superior pul*monary vein are ligated and severed and the third one is doubly ligated in continuity before being severed (broken line)

I' On completion of the ligation of the three tributary veins, the ligature encircling the superior pulmonary vein is tied. The retraction of the vein after severance of its tributaries exposes an additional branch of the pulmonary artery the anterior mediastinal (I and I') which arises opposite to, and in this patient is larger than, the apical-posterior branch, the ligated stump of which lies superiorly The anterior mediastinal artery is *now elevated on a clamp* prior to being ligated in continuity and severed.

J The ligation of the superior pulmonary vein and the double ligation and severance of its three tributary veins are completed. Also the anterior mediastinal artery has been *ligated in continuity and its branches have* been doubly ligated and transected between the ligatures.

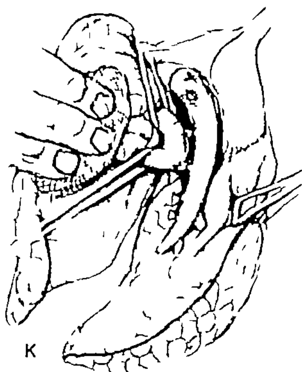
Discussion—Dr. Kirby (cont.)

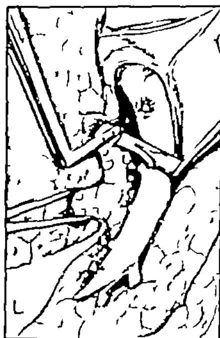
position of the axillary vein so that the dissection can be carried out with unusual care in this region. When an extrapleural dissection is necessary at the *apex of the chest It is of great importance to* be able to use the electrocautery Bleeding points on the inner surface of the ribs and intercostal bundles cannot be clamped and often cannot be dealt with very satisfactorily by suturing. Use of the electrocautery is usually ideal for dealing with such bleeding points The total operating time can often be greatly decreased. Without the electrocautery more time can readily be spent in trying to control the bleeding from the chest wall than in carrying out all the maneuvers which are actually necessary for removal of the lobe.

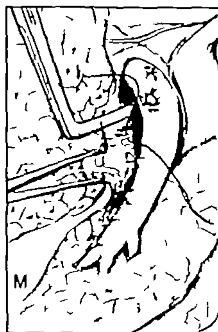
Mobilization of the left pulmonary artery and the segmental branches to the upper lobe have been well illustrated (D through F") Unfortunately the dissection is rarely so straightforward and clear-cut because there is an incomplete fissure between the upper and lower lobe, or there are many adhesions between the two lobes, in more than half of the patients. In either event, extensive dissection may be necessary before the pulmonary artery can be exposed in the depths of the fissure. The safest approach in opening up the fissure, in my experience, is to work from above downward The main trunk of the left pulmonary artery can be readily exposed where it curves around the left upper lobe bronchus before entering the fissure. A plane in the loose areolar tissue *overlying the pulmonary artery can be readily en*tered, and dissection along this plane can be safely carried down into the fissure for a short distance without the risk of dividing segmental branches. This also provides the surgeon an opportunity of clarifying the precise location of the fissure. It can usually be readily ascertained which is the upper and which is the lower lobe. Dissection can then be carried out preferably with the scissors, in the correct plane. Bleeders may be encountered, and, if so, they are clamped and ligated. Much of the dissection in the fissure can ordinarily be carried out without dividing bleeders. If the surgeon has identified the correct plane. Dissection is carried progressively downward along the pulmonary artery and in the fissure in this manner until the entire main trunk of the left pulmonary artery has been exposed.

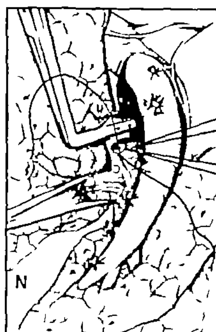
It has been my practice to place suture ligatures distal to the free ligatures on the segmental branches of the pulmonary artery Very little further time and effort is required The security provided by the use of suture ligatures has seemed worthwhile to me.

The superior pulmonary vein is sufficiently long.


K


L


M


N

K. The left upper lobe is retracted anteriorly and the interlobar fissure is again exposed The main stem bronchi to the superior (apical-posterior and anterior) and lingula (superior and inferior) segments are mobilized and encircled by cotton tapes

L. The superior branch bronchus, occluded by a clamp (Sarot) distally is being partially transected by a scalpel on a right angle handle

M N The open proximal end of the partially transected bronchus is occluded seriatim by sutures of 000 silk as the bronchus is serially transected.

DISCUSSION—DR. KIRBY (cont.)

in most patients, to permit application of one free ligature and one suture ligature to the main trunk. Double ligatures on the tributaries of the superior pulmonary vein have not usually been necessary (I J) but if a short main trunk of the superior pulmonary vein is encountered ligation of the individual tributaries proximally and distally is undoubtedly a wise precaution. More extensive dissection of the individual tributaries must be carried out in order to obtain an adequate cuff This dissection is not without risk and must be performed with great care.

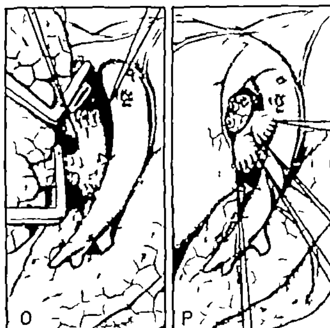
A somewhat different method of dividing and suturing the bronchus (L through P) has seemed preferable to me. The upper and lower divisions of the upper lobe bronchus are dissected out for some distance beyond the bifurcation as illustrated It is useful to use a "wiping" maneuver with gauze sweeping adherent parenchyma, peribronchial lymph nodes, and other peribronchial tissues peripherally Two Sarot clamps are then placed separately on both the superior and inferior divisions of the upper lobe bronchus, and both of these branch bronchi are then divided between the clamps with a scalpel. This permits removal of the entire upper lobe before bronchial suturing is commenced, and there is excellent exposure during bronchial suturing. The bronchial sutures are inserted with straight needles proximal to the bronchial clamps. After they have all been inserted beneath one of the clamps, the clamp is removed. Traction is applied to the sutures, which are neatly matched and handed to the operator serially by the first assistant, for tying.

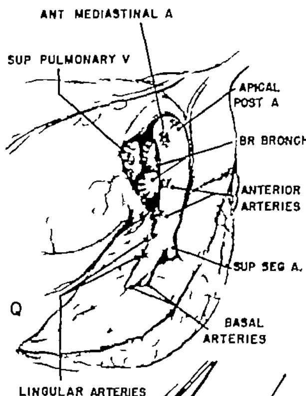
Pleuralization of the bronchial stumps has been generally considered an important factor in preventing the development of a bronchopleural fistula. I have always pleuralized the bronchial stump, and the incidence of this complication in my hands has been so low that I have been convinced about the importance of this step The left upper lobe bronchial stump is one of the most difficult to pleuralize because dissection of the superior pulmonary vein often causes lacerations in the portion of the mediastinal pleura that might potentially be the most readily available. I have avoided this difficulty by using a hinged flap of pericardium. The hinge is based just anterior to the phrenic nerve and a U-shaped incision is made up toward the anterior mediastinum This incision is made through the entire thickness of the pericardial sac and the flap is rotated on its hinge 180 so that the pleural surface near the tip of the flap covers the bronchial stump Sutures that are used to close the end of the bronchus are passed through the flap anchoring it securely in position It should be stressed that this is a flap of tissue with an adequate blood supply rather than a free graft. It is applied without tension in such a manner as to provide every opportunity for firm, early sealing of the bronchial stump.

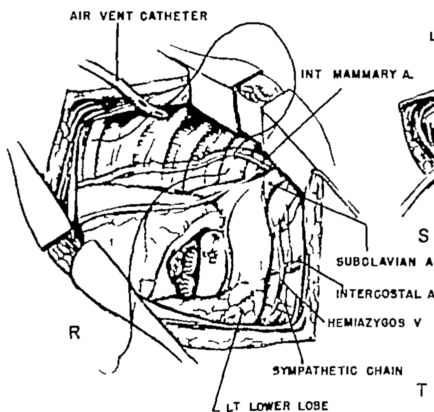
After the left upper lobe is removed the apex of the left lower lobe still lies a considerable distance from the apex of the chest (Q R) It is important to mobilize the left lower lobe so that it can rise to the top of the chest. In order to accomplish this the pulmonary ligament must be completely divided from the diaphragm right up to the inferior pulmonary vein It appears helpful also to divide the remaining portion of the pleura which is reflected on the hilum both anteriorly and posteriorly After this has been done, as the chest is being closed, the lower lobe will be seen to occupy the desired position. One additional maneuver that is employed by many surgeons is to paralyze the diaphragm temporarily by pinching the phrenic nerve a short distance above the diaphragm. This undoubtedly decreases the likelihood that there will be a residual collection of air or fluid on top of the left lower lobe.

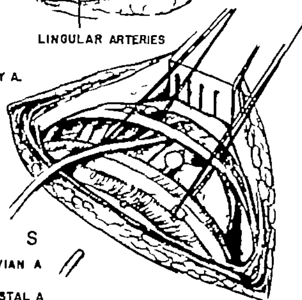
The use of an upper and lower tube, as illustrated, is strongly recommended Rather than bringing the upper tube out through the anterior end of the incision, as is illustrated and as I used to do it now seems preferable to me to bring this tube out one or two interspaces below the intercostal space which is actually opened.

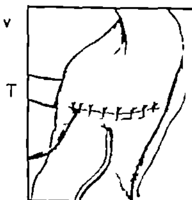
It has seemed advisable to apply suction to both the upper and lower chest drainage tube, but particularly to the upper drainage tube, following left upper lobectomy It is important to remove all air and fluid from the apex of the chest during the early postoperative period so that full expansion of the lower lobe can take place at the top of the left hemithorax When suction has not been used, there has been a persistent effusion on top of the left lower lobe in some instances.


O
P


ANT MEDIASTINAL A
SUP PULMONARY V
APICAL POST A
BR BRONCH
ANTERIOR ARTERIES
SUP SEG A.
BASAL ARTERIES
LINGULAR ARTERIES
Q


AIR VENT CATHETER
INT MAMMARY A.
SUBCLAVIAN A
INTERCOSTAL A
HEMIAZYGOS V
SYMPATHETIC CHAIN
LT LOWER LOBE
R


S


T

O. The closure of the superior stem bronchus is completed. The inferior or lingula branch bronchus will be occluded in like manner

P The closure of both stem bronchi is completed. They are held outward by traction on the angle closure sutures to show their relation to the surrounding structures.

Q The sutures are cut, and the occluded branch bronchi are allowed to recede into their normal relation to the pulmonary artery and the ligated stump of the superior pulmonary vein.

R. A catheter (18 F) is being anchored to the parietal pleura of the chest wall anteriorly to serve as an air vent.

S. The air vent catheter (18 F) and a Foley (No 18) catheter for underwater drainage of the pleural cavity are inserted, and closure of the costal cage is begun. Two double-strand pericostal sutures of No 2 chromic catgut are inserted through periosteal "windows" underlying the sixth rib The defect in the costal cage cephalad following segmental en bloc resection of the second, third and fourth ribs is visible The muscles of the posterolateral chest wall are closed in layers, using continuous double strand sutures of 00 chromic catgut.

T The skin incision is closed with interrupted sutures of 000 silk to complete the operation The exits of the catheters in relation to the incision are depicted.

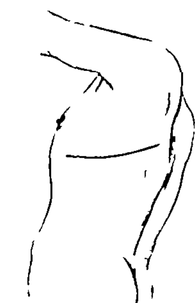
DISCUSSION—DR. JOHN C. JONES. An 80-year-old male complaining of constant pain in the axillary region for two months, having roentgenologic evidence of a peripheral lung lesion, must presumably have a lung malignancy of questionable resectability regardless of normal bronchoscopic findings. The reasons for consideration of resectional surgery are (1) to relieve the pain, (2) to eradicate the source of hemoptysis, and (3) to prolong life by resecting the malignancy and its local extension. Certainly the source of hemoptysis may be eradicated by surgical excision of the lobe, but it is by no means certain that the patient will be free of pain following surgery and debatable that an 80-year-old patient will live longer and as comfortably following radical resection of lung and chest wall as if he had been treated either by radiation and anticancer drugs or possibly radiation followed by excisional surgery

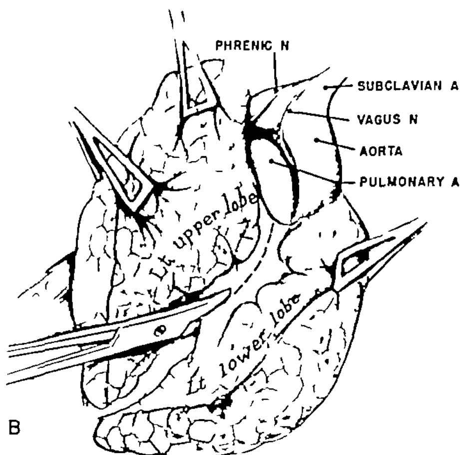
The extent of the en bloc excision of chest wall is dictated by the lesion involving it after the pleural cavity is explored and found free of malignant implants.

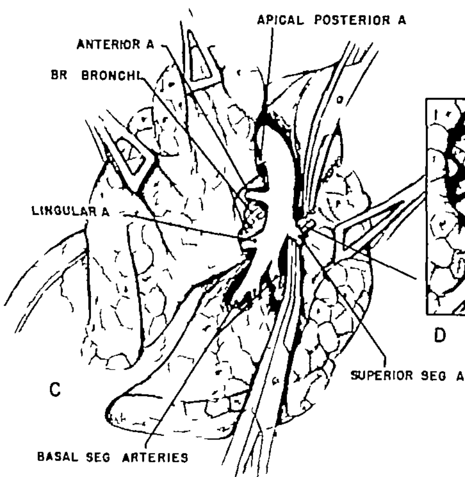
The segment of chest wall is excised and dropped into the thorax along with its contiguous lobe before the hilar dissection is carried out. The technic may be modified, depending on the bulkiness of the tumor the presence and status of the interlobar fissure, and the variations of the anatomy of the pulmonary artery branches. Not infrequently it may be expedient because of difficult exposure to delay the sectioning of one or both lingular arteries until after the bronchus has been dissected and divided. Some surgeons prefer to divide the superior pulmonary vein before beginning the dissection of the branches of the artery contending that the manipulation of the lobe during arterial dissection may be conducive to hematogenous metastasis. Only when the left upper lobe bronchus divides immediately near the main stem bronchus, or when carrying out segmental resection, do I employ the technic of a separate suture line for the superior and inferior segments of the left upper lobe. Peripheral malignancies confined to the left upper lobe that dictate lobectomy and most of them do, should have the bronchus severed as close to the main bronchus (preferably one suture line) as possible. I am a confirmed advocate of a short bronchial stump under all resectional circumstances, malignancy or infection.

It is most important to utilize the two (anterior and posterolateral) drainage catheters loosely sutured to parietal pleura in most lobectomies, but particularly in upper lobectomy They should be left in place until the remaining lobe, fully expanded, has obliterated the space defect at the apex. I prefer to have both tubes brought out through stab wounds (intercostal airtight drainage) rather than have either drainage tube emerge through the wound site The bony defect resulting from the resection is well protected by the scapula and shoulder girdle musculature, so a prosthesis is not needed.

Prompt obliteration of the residual space left by lobectomy will prevent the incidence of complications of resection (residual air space, bronchopleural fistula, hematoma, and empyema) Suction drainage is frequently indicated. Phrenic crush at the diaphragm may be considered, but I prefer to institute immediate pneumoperitoneum to encourage early elevation of the diaphragm for space filling purposes. Air leaks from crossing incomplete fissures may require strong suction to encourage early and rapid lung expansion of the remaining segment of lung. Long suture lines of pleural edges to obliterate small bronchial leaks compromise the volume of the remaining lung, deform the lung's natural contours, and are to be avoided if possible by individual ligation of the air leak points.


A


PHRENIC N
SUBCLAVIAN A
VAGUS N
AORTA
PULMONARY A
Lt upper lobe
Lt lower lobe
B


APICAL POSTERIOR A
ANTERIOR A
BR BRONCHI
LINGULAR A
SUPERIOR SEG A
BASAL SEG ARTERIES
C


D

PULMONARY LOBECTOMY LEFT LOWER LOBE

A. The patient is placed in the direct right lateral prone position, and the incision overlying the sixth intercostal space is outlined

B. The left pleural cavity is entered, and the severance of the visceral pleura overlying the interlobar fissure for the exposure of the pulmonary artery and its branches is shown

C, D The left pulmonary artery and its branches to the upper and lower lobes are exposed The artery to the superior segment of the lower lobe, which originates opposite the site of origin of the branch to the lingula segment of the upper lobe, is being encircled by a ligature of 00 silk (C) preliminary to its double ligation in continuity and severance (D)

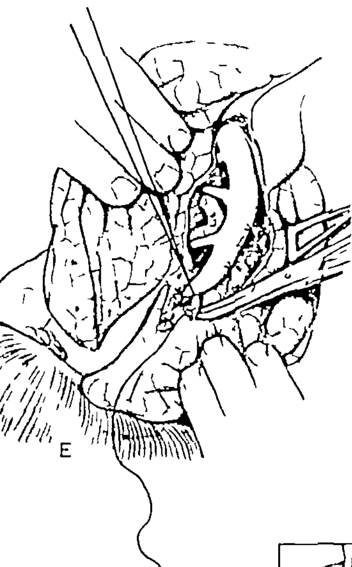
DISCUSSION—DR. JOHN C. JONES. In women the anterior extremity of the posterolateral incision should be carried low enough so that it is not beyond the mammary fold or into the breast area the incision should not cross above the angle of the scapula when the patient is in the normal upright position. In young patients I prefer the intercostal approach, incising the unresected rib bed of the sixth rib, but in older patients I usually resect the sixth rib The latter are not infrequently plagued with postoperative thoracic pain, particularly if rib spreaders are spread too rapidly or too widely

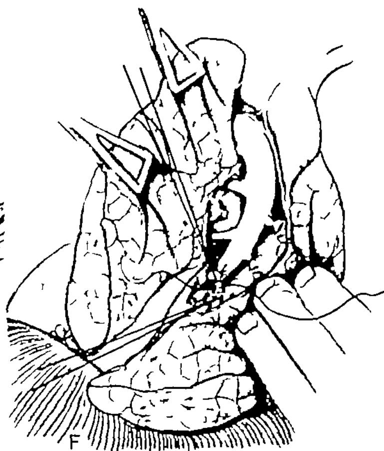
The dissection of the branches of the pulmonary artery will be guided by the completeness or incompleteness of the interlobar fissure, the extent and character of the lesion involving the lung, and the presence of hard fixed lymph nodes overlying the artery and its branches. Anticipating difficulties in the dissection, a tape passed about the main pulmonary artery or the main branch to the lower lobe will facilitate hemostasis and repair if branches of the artery are torn during the dissection. Usually the branch of the pulmonary artery to the superior segment must be divided first the main branch to the lower lobe may then be divided some distance distal to it and below the lingular branch. Segmental resections require meticulous dissection of the various branches. However most left lower lobectomies need only the ligation and division of the superior segment branch and the main branch to the lower lobe just distal to the lingular branch. I prefer to dissect the inferior pulmonary ligament up to the inferior vein and to clamp the mediastinal bleeders individually as they are encountered. Unless the superior segment is to be salvaged, the entire inferior pulmonary vein may be doubly ligated and divided. I place a suture ligature distal to the proximal tie

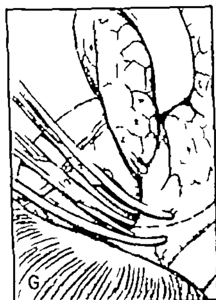
The vast majority of lower lobe bronchi I have transected have been closed with one suture line. I believe this technic to be preferable to first individually dividing and suturing the superior segment branch bronchus. This I prefer to do without a bronchial clamp, using two stay sutures, one just below the upper lobe bronchus (anterior) and another just above the superior segmental bronchus (posterior) If necessary I cut the bronchus on the bias, resulting in a short bronchial stump Since 1942, I have employed 00000 (35 gauge) stainless steel sutures on swage needles for bronchus closure except in infants, when I use 00000 arterial silk. This technic eliminates two bothersome late complications puddling of secretion in the long stump and bleeding from granulations at the sutured bronchial stump I have not known of a patient who expectorated a wire suture.

After the major hilar structures have been dealt with, the lobe to be resected is carefully dissected from its contiguous lobe or lobes gentle traction is applied to the bronchus clamp and the diseased lobe, and the smaller interlobar structures are divided individually as the dissection is carried along the interlobar fissure line, while the remaining lung is kept inflated with anesthesia positive pressure. It is much easier to dissect along the fissure line from the hilum outward to avoid tears and leaks in the lung tissue that is to remain.

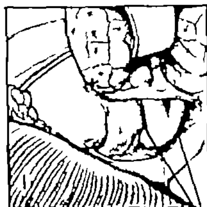
Pleural grafts are not always feasible, but I would prefer to do without a graft cover than to transplant fat or tissue under tension and doomed to die A bronchus not unduly denuded, with adequate bronchial blood supply to its stump end, properly sutured with stainless steel and with the surrounding tissues dropping over it, is most unlikely to be complicated The exceptions obviously are the resections in tuberculous patients whose organisms are resistant to antituberculosis drugs and patients in poor nutritional state.

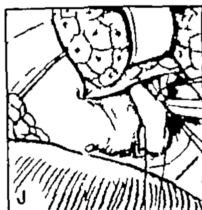

E

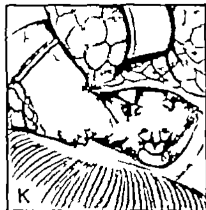

F


G


H




J


K

E. The remaining artery to the basal segment of the lower lobe is being doubly ligated in continuity

F. A transfixion suture ligature of silk (000) is inserted just beneath the proximal ligature, and the artery is cut (broken line) between the transfixion and distal ligatures.

G. The inferior pulmonary ligament is doubly clamped and severed (broken line) by scissors.

H I. The opening between the layers of the inferior pulmonary ligament is enlarged (H) to expose the inferior pulmonary vein, which is encircled by an untied ligature of 00 silk. (I)

J. The superior segmental tributary is doubly ligated in continuity (00 silk) and severed (broken line) between the ligatures.

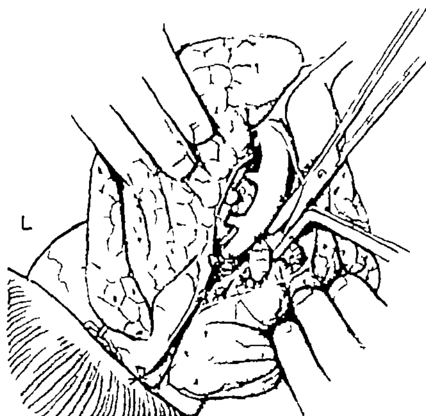
K. The larger tributary from the basal segment is occluded in like manner and the ligature (00 silk) that encircled the main trunk of the inferior pulmonary vein (I, J) is tied

DISCUSSION—DR. CHARLES K. KIRBY The technic of left lower lobectomy has been very well described and illustrated. Many of the points which I made in my discussion of pulmonary lobectomy left upper lobe, are also applicable here and are therefore not repeated.

The incision for left lower lobectomy may be made a little lower on the chest wall, and it may also be made shorter Adequate exposure is provided by entering through either the sixth or seventh intercostal space, whereas the fourth intercostal space is preferable for left upper lobectomy The reason why it is possible to make a shorter incision for left lower lobectomy is that it is not necessary to displace the scapula and shoulder upward for this procedure; nor is it necessary to open the rib spreader to such a great extent because dissection at the apex of the chest and at the superior and anterior aspects of the hilum are not necessary

Mobilization of the left upper lobe is not necessary in most instances. It is chiefly for this reason that left lower lobectomy in general, is a more benign procedure than left upper lobectomy When dissection at the apex of the chest is not necessary there is often considerably less blood loss and the patients seem to have less postoperative pain. In most instances of left lower lobectomy the entire dissection is confined to the lower portion of the left hemithorax, and this is probably why this procedure seems less traumatic and stressful. One qualifying statement is advisable, however: in some instances the left upper lobe may have been trapped to some extent because of a previous inflammatory reaction and/or effusion, when this is the case and the total volume of the left upper lobe has been significantly decreased, decortication of the left upper lobe may become necessary Under such circumstances, the magnitude of the entire operative procedure is increased to a considerable extent.

During the dissection of the segmental branches of the pulmonary artery in the depths of the fissure, it is necessary to retract the left upper and lower lobes in order to obtain adequate exposure, because inflation of these lobes by the anesthetist tends to interfere seriously with the clear visualization necessary for safe dissection. The application of lung clamps to the left upper lobe (B, C, F) has not in my experience been entirely safe. Potential injury to the pulmonary parenchyma, which is quite delicate, is more than a theoretical possibility and I have observed such an injury with a troublesome air leak. A satisfactory method of obtaining adequate exposure is to use broad bladed malleable retractors, with moist sponges to protect the lobes at the tip of the blades Sponge sticks, with loosely folded gauze inserted between the



L



M



N



O

L. The ligation and severance of the blood vessels to the lower lobe is completed. The interlobar fissure is again exposed, and the branch bronchus to the superior segment of the lower lobe is clamped (Sarot clamp) distally preliminary to its transection proximally with scissors. Closure of the branch bronchi rather than the main stem bronchus prevents encroachment upon the lumen of the bronchus to the upper lobe.

M. The bronchus is serially severed with scissors and occluded with interrupted sutures of 000 silk swedged on a minimum trauma needle

N The lower lobe is removed, and the final suture to complete the closure of the bronchus to its basal segment is inserted.

O. The suture lines of the occluded branch bronchi are covered with free grafts of pleura to lessen the hazard of leakage

Discussion—Dr Kirby (cont.)

blades, also are very satisfactory for holding the fissure apart It has seemed advantageous to have one person, such as the second assistant hold the fissure open he can control the inflation of both lobes to the extent desirable without risking injury If two assistants are retracting the lobes, there is sometimes a tendency toward the application of excessive pressure on one side or the other

Exposure of the main branch of the pulmonary artery and dissection of the segmental branches to the lower lobe are always somewhat hazardous. If there has been scar tissue formation in the depths of the fissure, the risk is somewhat greater The key that opens the door to a safe dissection, in my opinion, is to enter the correct plane on the surface of the pulmonary artery The precise location of this plane can only be learned by experience. In teaching younger men how to enter this plane I have discovered that there is an understandable tendency to think that it lies somewhat more superficially than is actually the case. In order to find this plane, it is often helpful to pick up the adventitia with a forceps, cut it superficially with dissecting scissors, and then separate the tissues with a curved clamp The surface of the pulmonary artery appears smooth and glistening when the proper plane has been entered. This plane can be safely followed up the entire length of the pulmonary artery and out on to the segmental branches by blunt dissection. It is essential to stay in this plane when going around the pulmonary artery Injury posteriorly appears to be a common technical complication for the inexperienced when they are attempting to go around the main basal branch of the pulmonary artery

It has been stated in some textbooks of anatomy that the pulmonary ligament is avascular This is usually not the case. As a rule, the pulmonary ligament contains only three or four vessels that need to be clamped, however so it is not necessary to clamp and ligate the entire ligament. There is nearly always a vessel at the diaphragmatic end of the pulmonary ligament, and it seems advisable to divide 2 cm of tissue in this area between clamps so that ligatures may be applied. The remainder of the pulmonary ligament can then be divided with scissors, bleeding points being clamped and ligated as they are encountered.

Whenever possible, the use of a free graft should be avoided in pleuralizing the bronchus (O) It is important to plan an adequate covering for the bronchial stump when beginning the posterior dissection of the hilum. Unless planning is begun at this time, all of the pleura and areolar tissue adjacent to the aorta may be shredded to such an extent that there will not be an adequate covering for the bronchial stump

INT MAMMARY VESSELS
PHRENIC N
VAGUS N
A
DIAPHRAGM
B
PERICARDIUM





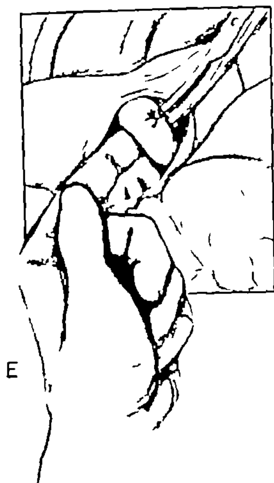
TOTAL PNEUMONECTOMY LEFT

A. The patient is placed in the direct right lateral prone position and the left postero-lateral thoracotomy incision is outlined and cross hatched to facilitate later closure

B. The left pleural cavity is entered through the fifth intercostal space (Brock technic) and the intrapleural viscera in relation to the surrounding viscera are depicted. The upper lobe of the left lung is manually retracted posteriorly and the mediastinal pleura overlying the pulmonary hilum is severed (broken line) by scissor dissection.

C. The severance of the mediastinal pleura is completed to expose the left pulmonary artery and the left superior pulmonary vein. The apical posterior branch of the pulmonary artery is mobilized and elevated on a clamp preparatory to being encircled by a ligature of 000 silk.

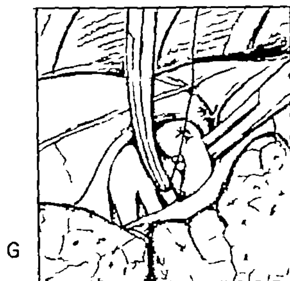
D. The apical-posterior artery doubly ligated (000 silk) in continuity is being severed (scissors) between the ligatures.



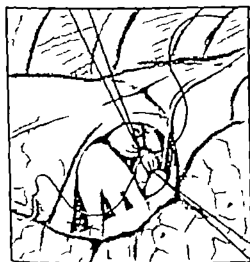
E



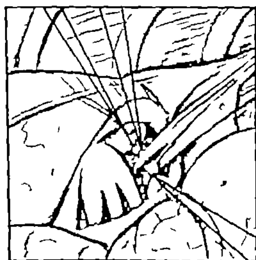
F



G



H



I

E, F G Pulmonary artery is being mobilized by *combined digital and clamp dissection* (E) and, finally by digital dissection alone (F) before being encircled (G) by a ligature of 0 silk. The use of blunt digital dissection, particularly in the plane posteriorly is a useful safe, and efficient method for mobilizing the large vascular trunks in the pulmonary hilum

H. The pulmonary artery is doubly ligated (0 silk) in continuity and a transfixion suture (00 silk) is being inserted between the ligatures but closer to the proximal ligature.

I. The pulmonary artery is transected with *scissors between the two proximal and* single distal ligatures.

DISCUSSION—DR. ALTON OCHSNER. Whereas the anterior approach in the fourth interspace can often be used for pneumonectomy the posterolateral incision is certainly preferable I prefer an incision that extends farther anteriorly than illustrated in A, as it gives a little better exposure generally The incision of the mediastinal pleura should be made in such a way as not to interfere with the phrenic nerve, which is easily identified (B) Generally I think it is desirable to extend the incision up to the apex of the pleural cavity and begin the dissection above in order to remove any lymph nodes in the superior mediastinum, because on the left side a large involved node is often found about the arch of the aorta. It is important to examine this area early during the dissection in order to determine whether the lesion is resectable even though involvement may be limited to the node it can extend to the aorta, and if the aorta is actually involved, resection is not justified.

Although branches of the pulmonary artery can be individually ligated (C D) it is generally my choice to isolate the pulmonary artery and ligate it as a common trunk. In every instance, however I use transfixion in addition to ligation, which is particularly necessary in large vessels, such as the common trunk of the pulmonary artery

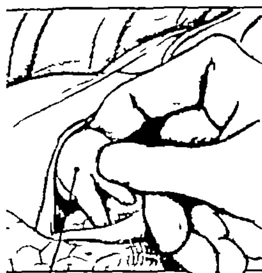
Digital dissection is by far the most important and certainly the safest method. After complete isolation of the pulmonary artery from the superior pulmonary vein and the bronchus (G) a curved instrument is placed under the pulmonary artery and the ligature is drawn around it It is imperative to ligate on the cardiac side and on the pulmonary side with as much room between the ligatures as is possible. This is facilitated if the surgeon places his index finger behind the artery "walks" the cardiac ligature into the mediastinum, and holds it in this position while the assistant ties the ligature Transfixion both on the cardiac and pulmonary sides is important in addition to ligation. In fact it is my custom to place two sutures proximally in such a way as to include four quadrants of the circumference of the vessel.

Generally before ligating the superior pulmonary vein, it is desirable to mobilize the lower lobe of the lung by incising the inferior pulmonary ligament (M) This may facilitate isolation of the superior pulmonary vein. Again, the digital dissection is of importance here as in the pulmonary artery and ligation of the main trunk using the transfixion suture (K, L) Branches of the superior pulmonary vein can be ligated and transfixed separately or if there is sufficient room, ligation might be done as a trunk distally

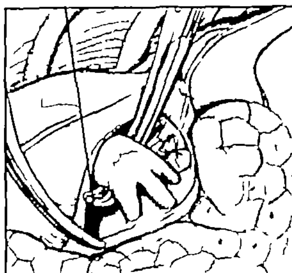
The inferior pulmonary vein is exposed by retracting the lower lobe anteriorly and, again using digital dissection, the vein is completely isolated, after which ligation and transfixion ligation are done

The bronchus is carefully dissected out, and all the nodes around the bronchi are removed together with the resected specimen. It is important that the bronchus be freed as far medially as possible up to the bifurcation because of the possibility of spread proximally One can either utilize one bronchial clamp (P) or two one placed proximally and the other distally If the proximal clamp is used it should not be applied tightly enough to crush the bronchus, however The sutures introduced in the end of the bronchus (Q) should be tied only tightly enough to approximate the edges of the bronchus and not so tightly as to cut through the bronchus.

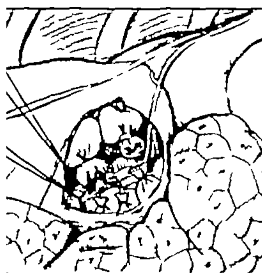
After removal of the lung and completion of the bronchial suture, it should be determined whether the suture is airtight This is done by filling the thoracic cavity with saline solution and having the anesthetist increase the intrabronchial tension If there is any leakage, bubbles will appear Covering the bronchus with a flap of pleura is imperative in order to facilitate healing and prevent subsequent blowout of the bronchus. It is my policy after completion of this phase of the procedure, to close the wound, leaving a catheter at the anterior end of the wound. The catheter is left in place until the wound has been completely closed and the patient placed back in a supine position The anesthetist then inflates the opposite lung, which brings the mediastinum back into the midline position, during which time the catheter is kept open to permit egress of the trapped air While the sound lung is maintained in the standard position the catheter is withdrawn and the area sealed with vaseline gauze



J



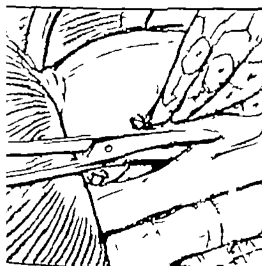
K



L



M



N



O

J K. The superior pulmonary vein is mobilized posteriorly by blunt digital dissection (J) and then partially encircled by a clamp (K) for the withdrawal beneath it of a ligature of 0 silk

L. The ligature (0 silk) about the superior pulmonary vein is tied, and its tributary veins are doubly ligated (000 silk) in continuity and severed (broken line) between the ligatures.

M, N The lung is retracted medially and cephalad to make taut the inferior pulmonary ligament, which is doubly clamped and severed (M) to enter the posterior mediastinal space The opening in this space is extended cephalad (N) to obtain exposure of the inferior pulmonary vein that forms the upper boundary of the inferior pulmonary ligament.

O The inferior pulmonary vein is isolated, and its main trunk is occluded with a ligature of 00 silk. The tributary veins, superior *(being severed with scissors)* and basal, are doubly ligated (000 silk) in continuity and transected (scissors) between the ligatures.

DISCUSSION—SIR RUSSELL BROCK. After identification of the vagus and dissection and clamping of the bronchus, the pleural incision is carried upward to the apex anterior to the vagus, the phrenic *nerve and vessels are secured as on the right side,* and the incision is then continued down in front of the phrenic nerve as far as the lower limit of the hilum, where the nerve and vessels are ligated and divided.

The pericardium is now opened and the veins dealt with as described for the right side, a common pulmonary venous trunk being easily displayed.

Once again it is preferable not to open the hilar areolar tissue to secure the upper lobe arteries as a preliminary to encircling the main left pulmonary artery This is done more efficiently as far medially as possible. Indeed, this technic may make it possible to remove a cancerous lung that otherwise could not be resected.

The incision in the pericardium is carried high up into the concavity of the aortic arch, in front *of the origin of the left pulmonary artery so as to* expose the ligamentum arteriosum. At this time it may be an advantage to clear the contents of the subaortic fossa carefully identifying, freeing, and conserving the left recurrent laryngeal nerve. Occasionally heavy lymph node involvement may compel division of the nerve as well as the main vagus. Some surgeons prefer to free and to divide the ligamentum arteriosum in order to make a more radical clearance of the subaortic fossa. Usually an adequate clearance can be obtained without dividing the ligament, which is usefully preserved so that the most proximal ligature on the artery can be placed *medial* to it. There is little difficulty in defining the ligament by working from in front, from above and from behind. It will then be found that the left pulmonary artery is almost completely free, and a little more dissection enables it to be encircled and a transfixion ligature *applied and the artery divided lateral to this.*

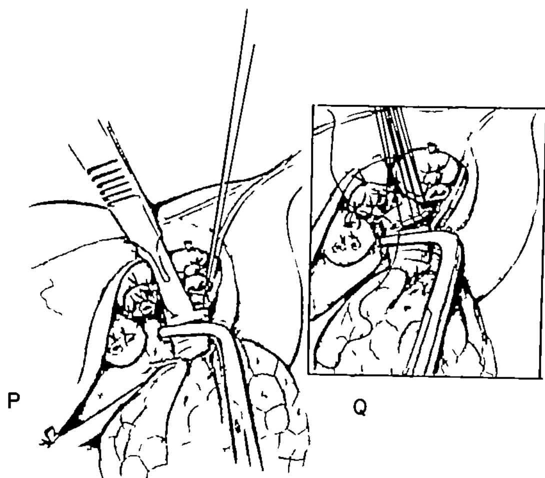
It is always safer to apply *two* ligatures, one of which transfixes the vessel on the central end of the artery and of the veins.

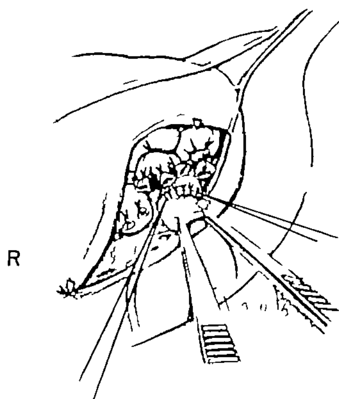
The further steps of incision of the pericardium and clearance of the ligamentum latum and of the inferior tracheobronchial fossa are as described for the right side. The bronchus stump is similarly treated.

My own preference after pneumonectomy is to insert a drainage tube but *not* to leave it open all the time. If it is left, open air is expelled on coughing or straining and overdistention of the remaining lung occurs.

The tube should be clamped except for a few seconds every hour or so when it is released to permit adjustment of pressure if there has been an increase from blood or serous collection. In other words, *the drainage tube is used virtually as a* manometer and safety-valve adjustment. It should be removed 18 to 24 hours after operation.

It is necessary to emphasize that, although the technic of dealing with the vessels may be thought to be too bold and too radical, it is in fact a simpler and safer method than dissecting within the hilum itself especially when, as is often the case, this region is distorted and rendered rigid by adjacent growth. By working as near the origin of the vessels as possible, the tissues are less likely to be abnormal and are more easily dissected, and a much more radical clearance of diseased tissue is achieved.

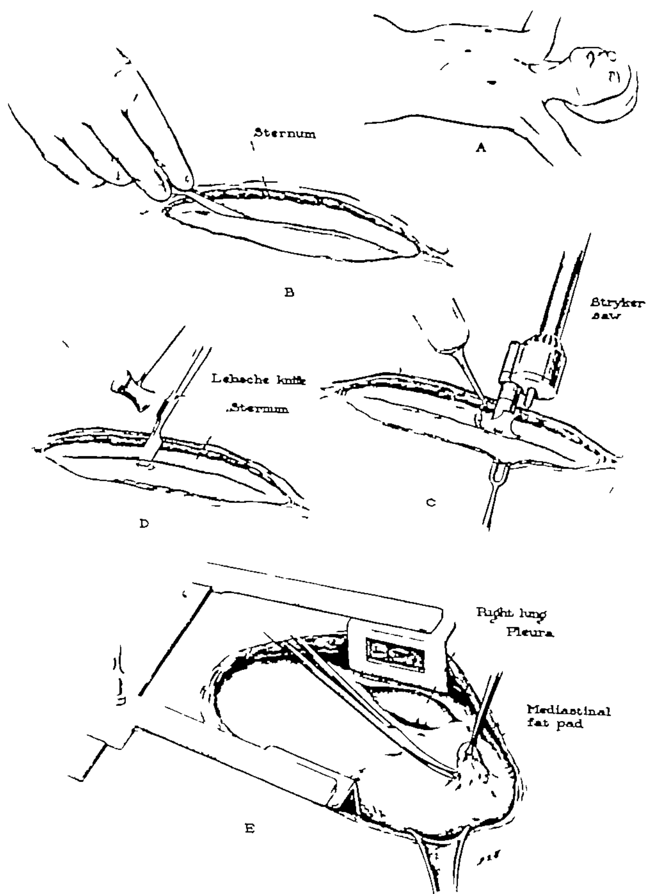

P
Q


R

P Q The left lung, now attached by its bronchus only is displaced posteriorly and the main bronchus is occluded by a clamp (P) Proximal to the clamp, the bronchus is being severed and its open end serially occluded with interrupted sutures of 000 silk (P Q) swedged on a minimum trauma needle

R. The closure of the bronchus is completed, and traction is maintained on the angle sutures as a free graft of pleura is being applied over the suture line. The closure of the wound completes the operation. Water seal drainage of the pleural cavity is not employed. However on completion of the wound closure, a negative pressure in the pleural cavity is established by aspiration with a syringe of the necessary quantity of air This is indicated when the glass plunger is slowly drawn into the barrel of the syringe on inspiration.

Discussion—Dr. William F Rienhoff Jr. In reference to left total pneumonectomy the anterolateral incision is again preferred, and the same suggestions hold for the left side as for the right. Other than the exceptions stated, I greatly approve of the technic as illustrated.


Sternum
A
B
Stryker saw
Lebsche knife
Sternum
C
D
Right lung
Pleura
Mediastinal fat pad
E

THYMECTOMY

The patient, a nine-year-old girl, had symptoms of myasthenia gravis of eight months duration that were becoming progressively worse in severity Because of the sex and age of the patient and the short duration and progressive character of the symptoms, thymectomy was advised Prior to admission to the hospital, the patient was taking two tablets (120 mg.) of Mestinon (pyridostigmine bromide) three times daily Two days subsequent to admission, Prostigmin (neostigmine bromide) one tablet (15 mg.) three times a day was substituted. The symptoms of dysphagia, dysarthria, and difficulty in breathing rapidly worsened. The Prostigmin (neostigmine methylsulfate) was then administered intramuscularly in the dose of 0.5 mg every four hours within 24 hours the dose was increased to 1.5 mg. every two hours. The difficulty in respiration persisted, and the use of an Emerson cuirass type of respirator was necessary Accordingly immediate thymectomy was done

Admittedly the performance of a thymectomy as an emergency operation may be questioned. However the rapid deterioration in the general condition of the patient despite adequate medical treatment seemed to justify the surgical risk.

On the first postoperative day a tracheostomy was required because of the excessive bronchial secretions. It was originally planned to do a tracheostomy immediately upon completion of the thymectomy However the general condition of the patient appeared satisfactory and it was not done This proved an error in judgment. Whenever a thymectomy is performed for myasthenia gravis, in particular when respiratory difficulty is manifest, tracheostomy is believed mandatory

On the second day after operation the patient was placed in a Drinker respirator and maintained therein for 12 days. Gavage feedings for 14 days were required Prostigmin (neostigmine bromide) was administered in 1.5 mg. doses intramuscularly first every two hours, then every three hours, for 12 days. It was then given by mouth, the dosage being two tablets (30 mg.) every two hours. Because of the excessive bronchial secretions, the medication was changed to Mytelase (abenonium chloride) and two tablets (20 mg.) every three hours were prescribed. The patient, now 18 months postoperatively is very satisfactorily maintained on the oral ingestion of two tablets (20 mg) of Mytelase (ambenonium chloride) four times a day

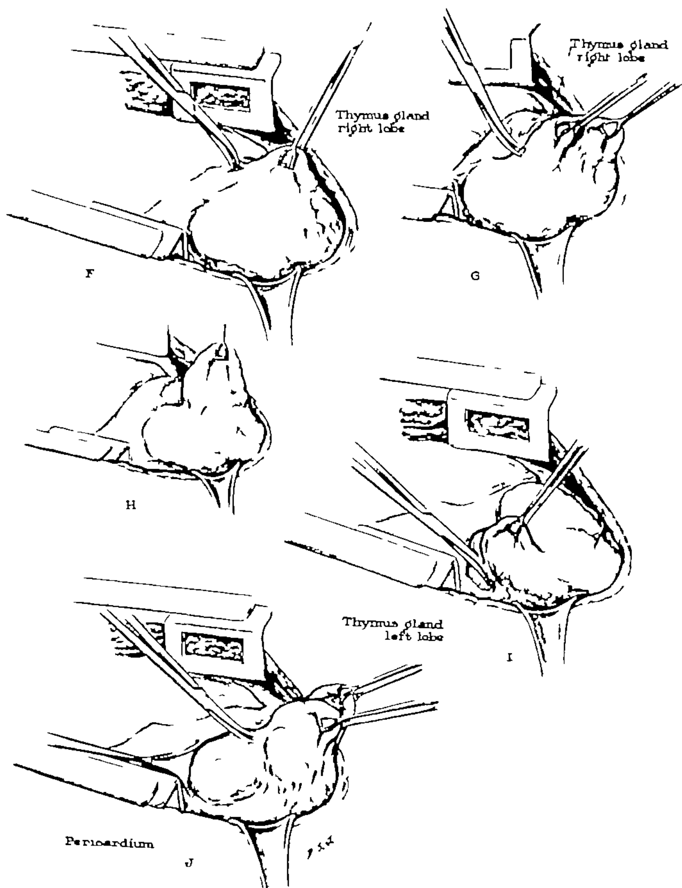
A. The patient is placed in the supine position and the midline sternal splitting incision (Duval Barasty) is outlined An alternate method for exposure of the thymus would be the use of a separate transverse "collar" incision and transection of the sternum in the fourth interspace the level at which the midline sternal splitting incision would terminate

B The incision is deepened through the thin subcutaneous fatty tissue layer and both the fascia and periosteum overlying the sternum are being incised.

C. The Stryker electric saw is used to split the sternum as sterile saline is being dripped to "lubricate" the cutting edge of the instrument.

D Using a Lebsche knife, the initial split in the sternum is completed.

E. The cut margins of the sternum are separated with a self retaining retractor (Finochietto) and the dissection of the mediastinal fat pad, which should not be mistaken for the thymus gland, is begun. An opening was inadvertently made in the right pleural cavity as depicted Entrance into one or even both pleural cavities is not uncommon with this type of incision, which theoretically should preclude its occurrence


Thymus gland
right lobe
F
Thymus gland
right lobe
G
H
I
Thymus gland
left lobe
Pericardium
J

F The dissection of the fat pad is completed. The right lobe of the gland is grasped in a Potts type of Babcock clamp * and, as upward traction is maintained, it is mobilized from the adjacent tissues by scissor dissection.

G H. A second "vascular" clamp is applied to the partially mobilized gland, and its dissection is *completed.*

I. The left lobe is similarly grasped in a "vascular" clamp, and its dissection is begun.

J Traction is maintained cephalad on both lobes of the thymus gland, which are dissected *from* the underlying anterior surface of the pericardium. The pericardium is easily recognized by its bluish sheen and vascular pattern.

Manufactured by Edward Weck & Co Long Island City N Y

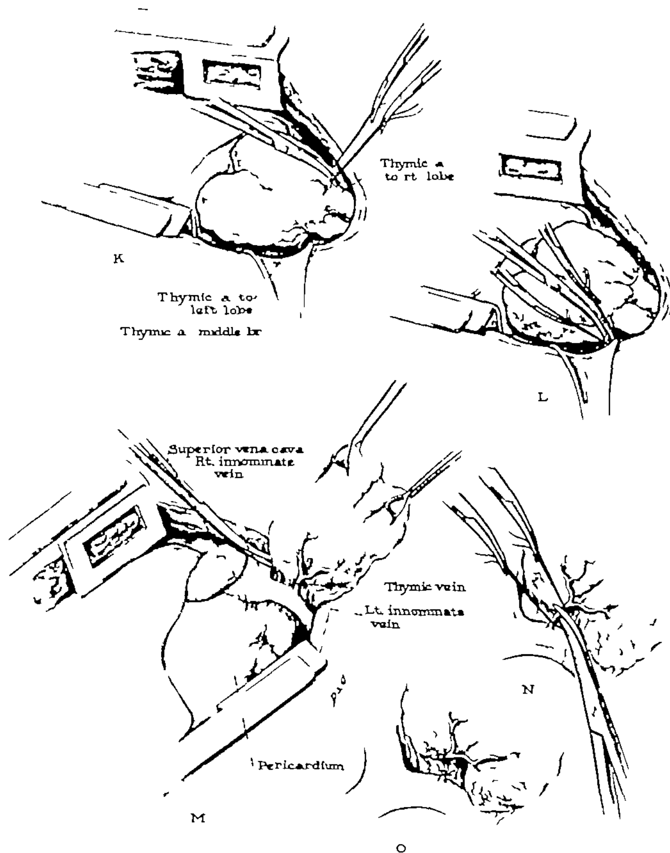
DISCUSSION—DR. MERLE M MUSSELMAN Thymectomy *may be accomplished with facility* as illustrated so well by Dr Madden. The operation itself poses little threat to the life of a patient Patients die after the operation from pulmonary complications resulting directly or indirectly from the myasthenia. As suggested by Dr Madden, operation should be planned when possible as an elective procedure during a remission. With proper preparation, technic of anesthesia, technic of operation, and postoperative care, the operation should carry little risk A crisis either before or after operation is a grave complication in a patient with myasthenia gravis. Because of the weakness of the respiratory muscles, including the diaphragm, the patient cannot ventilate adequately and cannot clear secretions from the trachea and bronchi Accordingly atelectasis, pneumonitis, and asphyxia are associated *complications.*

It must be emphasized *that a crisis may result* from progress of the disease (*myasthenic crisis*) or from overtreatment with anticholinesterase *drugs (cholinergic crisis) It is most important* that a distinction be made between the two which may be differentiated by the history and examination of the patient. However both the symptoms and the physical findings are so similar that a correct diagnosis is difficult to make.

Fortunately one can usually differentiate *cholinergic* from myasthenic crisis by the Tensilon Test. One hour after the last dose of cholinergic drug, 0.2 mg. of Tensilon is given intravenously If the *patient* has been overtreated, weakness will increase muscle fasciculation will appear and parasympathetic side reactions will occur If the patient is undertreated, muscle strength will increase without fasciculation.

In the treatment of a crisis of either type, early tracheostomy as an elective procedure should be *done as soon as the patient shows the first signs of respiratory difficulty One should initiate positive* pressure ventilation using a cuffed tracheostomy

Tensilon is the trade name of Roche Laboratories for edrophonium chloride


Thymic a
to rt lobe
K
Thymic a to
left lobe
Thymic a middle br
L
Superior vena cava
Rt. innominate
vein
Thymic vein
Lt. innominate
vein
Pericardium
M
N
O

When the dissection posteriorly is completed, the lobes of the thymus are reposited to their normal position, and the artery to the right lobe is first doubly ligated in continuity (000 silk) and then severed between the ligatures.

The artery to the mid-portion and body of the thymus has been similarly ligated and severed, and the artery to the left lobe is being transected between ligatures of 000 silk. The arteries to the thymus gland are branches of the superior and inferior thyroid arteries and the internal mammary artery

M. The mobilized gland is again retracted cephalad to expose its venous drainage, which in this patient was a solitary tributary vein of the left innominate vein.

N O The thymus vein is doubly ligated (000 silk) in continuity and severed between the ligatures.

DISCUSSION—DR. MUSSELMAN (cont.)

be. If myasthenic crisis cannot be controlled by e use of Prostigmin Methylsulfate intramuscu rly or Mestinon Bromide † intravenously it ould be treated as a cholinergic crisis. In pa ents who have a cholinergic crisis, all medication ould be stopped. After 72 hours the ventilatory sistance should be discontinued and the patient served for his ability to get along without medi tion If necessary treatment with cholinergic rugs should be started again in low to moderate osages, monitoring the results by the clinical re ponse and by the Tensilon Test. The cholinergic rug should be given parenterally when necessary ut orally otherwise

If thymectomy is to be done, on the morning of peration, the patient is given a cholinergic drug arenterally in a single dose that is calculated to aintain spontaneous respirations until the time of duction of anesthesia. Narcotics and barbiturates hould be used, if at all, in small doses Although elladonna-like drugs ha e the desirable effect of educing the excess bronchial secretion produced by the cholinergic drugs, they should not be used, because they have the undesirable effect of thick ening the bronchial secretions.

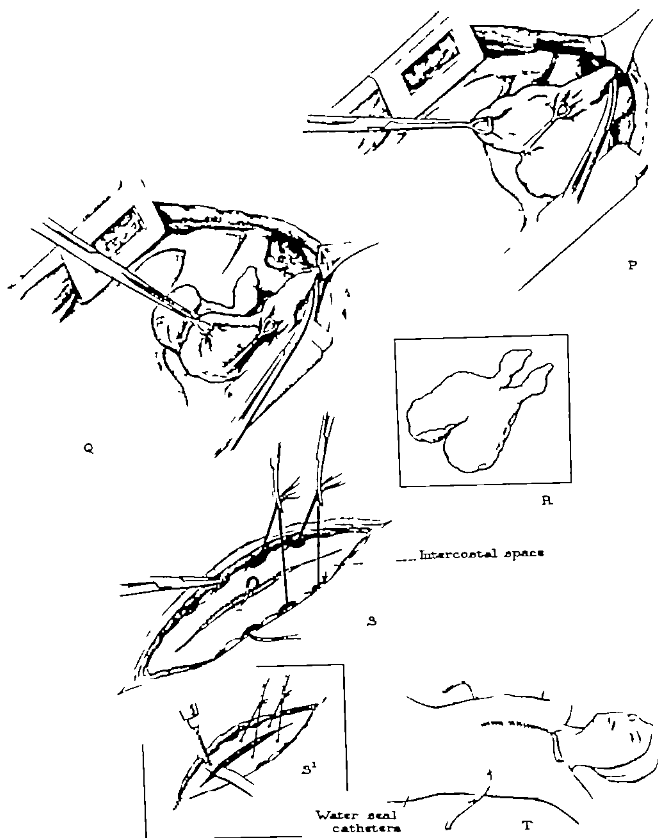
Cyclopropane has proved to be a good anesthetic, as it is easily administered, causes little irritation, and has little curare effect. Muscle re laxation is not necessary for thymectomy and muscle-relaxing drugs of either the curare or suc cinyl choline types should not be used. In fact, their use is contraindicated.

In the postoperative care most patients do not require cholinergic medicine for 24 hours after operation because of the remission of symptoms. As the symptoms reappear the parenteral use of cholinergic drugs is again started. One should undertreat the patient, giving only enough medicine to maintain respiration Dosage should be checked repeatedly by the Tensilon Test Myasthenic crises and cholinergic crises in association with inadequate ventilation, atelectasis, pneumonitis, and asphyxia are the greatest dangers after operation. They should be treated as previously described.

Prostigmin Methylsulfate is the trade name of oche Laboratories for neostigmine methylsulfate

Mestinon Bromide is the trade name of Roche aboratories for pyridostigmine bromide

Plate 42



P Downward traction is made on the right lobe as the attachments (avascular) of its *superior pole are being freed by scissor dissection* The thymus gland and also the parathyroid glands originate embryologically from the third branchial pouch. During fetal development the thymus descends downward behind the thyroid gland and terminates in the superior mediastinum. This explains the attachments of the superior poles of the gland, which extend cephalad on either side of the trachea to the level of the thyroid gland. The common site of origin of the thymus and parathyroid glands also explains the presence of parathyroid glandular tissue with the thymus in the superior mediastinum, which occurs in approximately 10 per cent of the patients

Q Similarly the superior pole of the left lobe is mobilized and the gland is removed. Total removal of the gland is believed most important, both in the treatment of myasthenia gravis and thymomas.

R. Inset to show the resected gland, which weighed 25 g. This is in the range of the normal weight at puberty of 25 35 g. On *histopathologic examination of the thymus*, lymphoid hyperplasia, lymph follicle, and germinal center formations, the characteristic findings in myasthenia gravis were present.

S. The sternal incision is closed using peristernal sutures (double strands) of No. 2 chromic catgut. The age of the patient (nine years) and the corresponding pliability of the chest cage permitted approximation of the cut margins of the sternum without difficulty

S' An alternate method for the closure of the sternal incision using interrupted stainless steel wire (gauge 26) sutures.

T The closure of the operative incision is completed. The pleural cavities, having been entered, are drained by water seal catheters A subcutaneous rubber tissue drain has its exit in the cephalad angle of the incision.

Discussion—Dr. O Theron Clagett The development of myasthenia gravis in a nine-year-old child is relatively uncommon. However this disease can occur at any age, even in newborn infants While sudden worsening of the symptoms of myasthenia gravis can occur one might suspect in this case that the sudden worsening might be related to the change in therapy from Mestinon to Prostigmine

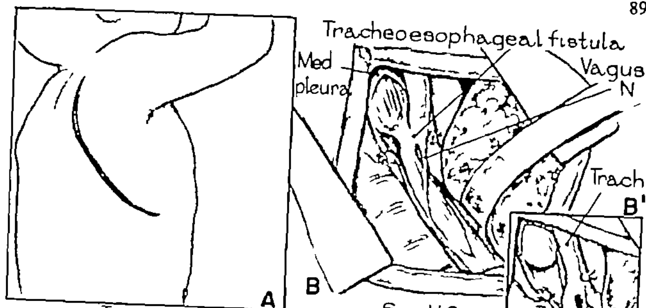
The wisdom of performing emergency thymectomy under the circumstances can be questioned. Patients with very severe myasthenia gravis can be carried along satisfactorily with assisted or controlled respiration for long periods of time, if necessary and the operation can then be performed under more favorable circumstances, with the disease in remission or at least under better control The effect of thymectomy on myasthenia gravis is so unpredictable and the time after operation when improvement appears varies so much that it would seem unlikely that thymectomy should be considered an emergency or life-saving procedure

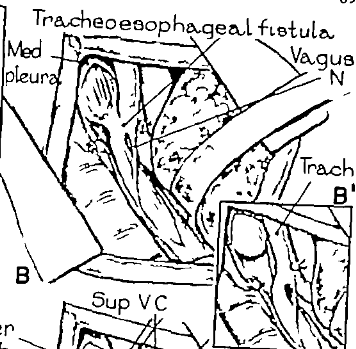
It would have seemed logical to perform tracheostomy at the time of thymectomy rather than *on the following day Tracheostomy is indicated in* all instances of severe myasthenia gravis.

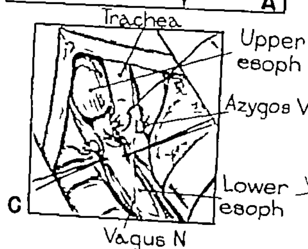
Postoperative management with controlled respiration, aspiration of tracheal secretions, and gavage feedings is highly appropriate. In patients with prolonged difficulty in swallowing, a small feeding gastrostomy has some advantages over the use of an indwelling nasogastric tube over many days.

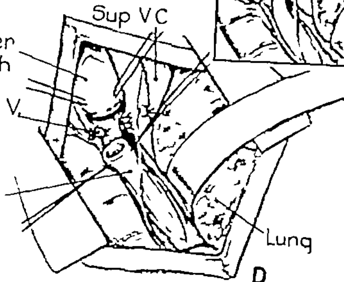
Since this child requires approximately the same amount of Mestinon eighteen months after operation as before thymectomy it does not appear that thymectomy has been effective in this patient. In my experience with this procedure, benefit has become apparent within six months of operation in the group that have been improved.

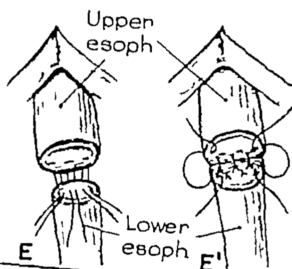
The technic of operation described is very appropriate and satisfactory It must be appreciated that, regardless of the thoroughness of the surgical attempt to remove the entire thymus, some thymic tissue may be left behind Thymic tumors occasionally develop out along the major bronchi or even in the lung parenchyma, so it seems inevitable that thymic tissue in ectopic sites may be left behind. Whether this may influence the effectiveness of thymectomy upon the course of myasthenia *gravis is not known.*

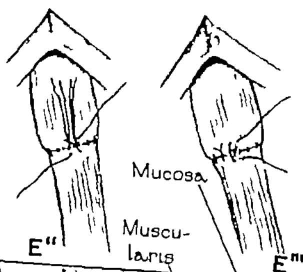

Tracheoesophageal fistula
Med pleura
Vagus N
A
B

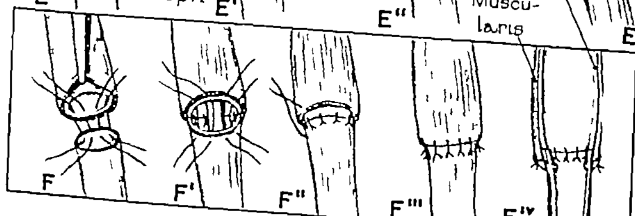

Trach
B'


Trachea
Upper esoph
Azygos V.
Lower esoph
Vagus N
C


Sup VC
Lung
D


Uppen esoph
Lower esoph
E
E'


E''
Mucosa
Muscu-
laris
E'''


F
F'
F''

CONGENITAL ATRESIA OF THE ESOPHAGUS WITH TRACHEOESOPHAGEAL FISTULA

A. The patient is placed in the direct left lateral prone position, and the right thoracotomy incision is indicated by the solid line. A transpleural rather than an extrapleural approach is preferred.

B. The right pleural cavity is entered and the azygos vein is severed between ligatures of silk (000). The site of the tracheoesophageal *fistula and the adherence of the narrow* proximal end of the lower portion of the esophagus to the widened cul-de sac formed by the distal end of the proximal portion of the esophagus are shown

B' Similar view as in B in a patient in whom the distance between the esophageal segment is greater To bridge this distance the upper rather than the lower segment is extensively mobilized because otherwise there would be danger of compromise of the circulation to the lower segment.

C. The proximal end of the lower portion of the esophagus is severed in an oblique plane from its communication with the trachea, and the opening into the tracheal lumen is closed with interrupted sutures of silk (0000) which are swedged on minimum trauma needles To obtain an adequate sized diameter of the lumen of the lower segment, a resection of a narrow portion of its proximal end, although not shown is usually required

D The closure of the opening in the trachea is completed and traction guy sutures of silk (000) are inserted in the walls of the proximal and distal segments of the esophagus preliminary to the performance of the end to-end anastomosis. The site of the incision to be made into the lumen of the proximal segment is indicated by the dotted line

E, E' E'' E''' These close up views depict the details of the end to-end anastomosis of the esophagus The first posterior layer consists of a series of interrupted mattress sutures which are all first inserted before being tied (E) These sutures produce an inversion of all of the layers of the esophagus into its lumen The mattress sutures are tied and interrupted sutures of silk (000) which include all the layers of the esophagus are inserted and tied These sutures form the second posterior layer of the anastomosis (E') and are continued anteriorly as the first anterior layer Although not shown in the illustrations, before inserting the first anterior layer of sutures, an intraluminal catheter (No 8F) is inserted to facilitate the completion of the anastomosis anteriorly When this is done, the catheter is removed The sutures forming the first anterior layer are inserted from the "inside out" to the "outside in" so that when tied the knots are *on the inside of the lumen (E') Each* suture is inserted alternately from either end toward the center to avoid an angle closure of the anastomosis When the last two sutures are tied in the midline anteriorly they are encircled by a reinforcing figure of 8 mattress suture of silk (000) before being cut (E'') The mattress suture is tied and the long ends are cut to complete the first layer of the anastomosis For the second anterior layer interrupted horizontal mattress sutures of silk (000) are used (E''') These sutures are inserted at right angles to the longitudinal layer of muscle fibers of the esophagus to obtain maximum holding power

F F' F'' F''' F'''' This series of close-up views illustrates the "telescoping" technic described by Haight in the performance of an end to-end anastomosis of the esophagus Interrupted sutures of silk (000) are used for the first posterior layer These sutures are all first inserted before being tied and include the mucosa layer only of the dilated proximal end of the esophagus and all of the layers of the narrow distal end of the esophagus (F) A catheter (No 8F) is passed from the lumen of the upper segment of the esophagus into the lumen of the lower segment and a similar series of sutures is inserted anteriorly (F') to complete the first anterior layer of the anastomosis (F'') The second layer of the anastomosis, both anteriorly and posteriorly consists of a series of interrupted sutures which are inserted through the muscular layer only of the upper segment of the esophagus and through the whole thickness of the wall of the lower esophageal segment caudad to the level of the first layer of sutures (F'' F'''). When tied, these sutures produce a "telescoping" of the narrow distal end of the esophagus into the wide proximal end which is best illustrated by a sagittal view of the completed anastomosis (F').

DISCUSSION—DR. CAMERON HAIGHT The repair of congenital atresia of the esophagus with tracheo-esophageal fistula can be performed readily through either a transpleural or extrapleural approach The individual choice of the surgeon will usually dictate the type of exposure that is selected My preference is for the extrapleural approach after the resection of the posterior half or two-thirds of the fourth rib for the reasons that the exposure is entirely adequate the anesthesia can be conducted more smoothly and, most importantly leakage of the anastomosis, should it occur postoperatively can be dealt with more readily by simple drainage of the extrapleural wound and with a lower mortality than if a total empyema were to occur following the transpleural operation The incision need not be started as high, as illustrated in A.

When a tracheoesophageal fistula is present, a primary esophageal anastomosis is almost always possible, providing adequate mobilization of the two portions of the esophagus is obtained should it be necessary A single-layer anastomosis (not illustrated) is used by some surgeons. Although it probably results in a lower incidence of stricture than does the two-layer anastomosis, it may result in a higher incidence of leakage. The thinness of the wall of the lower esophagus and the amount of tension on the anastomosis, should this be unavoidable, may govern the choice of the type of anastomosis that is used, and in these instances a single layer may be preferable When there is adequate tissue for a two-layer anastomosis, the "telescoping type illustrated in F Γ^{lv} is preferable, although the suture material should not be larger than 000000 silk on the smallest available arterial needles. All knots of the inner layer should present within the esophageal lumen The extrapleural wound is optimally drained with a No 14 F catheter and underwater suction for the first 24 to 36 hours.

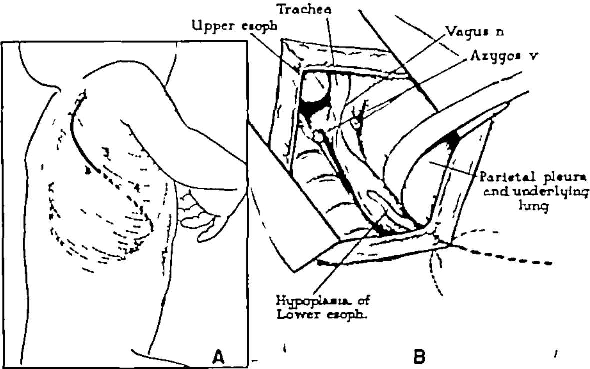
In the surgical management of congenital atresia of the esophagus, the selection of the mode of surgical approach is determined mainly by the plain roentgenogram of the abdomen. In the absence of gas shadows in the gastrointestinal tract, a primary anastomosis of the esophagus is not considered. A primary esophagogastrostomy employing a right transpleural approach is preferred. In the presence of gas shadows in the gastrointestinal tract, an extrapleural thoracotomy on the right side may be employed, and if possible, a primary anastomosis of the esophagus is performed. However in a certain percentage of the patients in this group, a primary anastomosis of the esophagus may not be possible because of the wide separation of the esophageal segments If this should obtain, a transpleural extension of the incision is recommended and the stomach mobilized into the right pleural cavity If following the mobilization of the stomach, the distal end of the esophagus is viable and the diameter of its lumen is adequate a direct anastomosis of the esophagus may be performed. Otherwise a primary intrapleural esophagogastrostomy is preferred. It is believed that every attempt possible should be made to reestablish continuity of the alimentary canal before resorting to a lifesaving multistage procedure

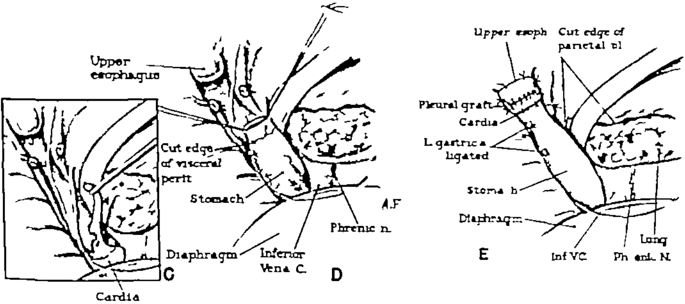
DISCUSSION—DRS. JOHN M BEAL AND CRANSTON W HOLMAN. Prematurity and aspiration pneumonia may present serious problems in the newborn infant who requires surgical correction of this congenital defect For this reason, judicious preoperative preparation for 4 to 48 hours with antibiotics and parenteral fluids is usually indicated

A right lateral transpleural approach through the fourth intercostal space gives the best exposure and requires less time These are important considerations in operations upon small patients To facilitate the anesthesia, the first step in the operation is to occlude the tracheoesophageal fistula which may easily be done by passing a small tape around the lower esophageal segment just below the tracheal communication This prevents loss of the anesthetic agent, improves the respiratory exchange and materially aids the anesthesiologist in the management of the patient

The text has emphasized adequate mobilization of the esophagus An anastomotic breakdown is more likely due to excessive tension than to the impairment of the blood supply resulting from mobilization of the esophageal segments. After the closure of the tracheal opening and completion of the esophageal anastomosis, it is desirable to place a flap of pleura between the esophageal suture line and the tracheal closure This may be helpful in the prevention of a recurrence of the fistula

A gastrostomy should be performed when the chest is closed. This permits early feedings which provide adequate nutrition until the oral intake is sufficient to satisfy the bodily needs. The operation is readily accomplished through a short left upper quadrant incision. A No 12 F catheter is inserted through a small incision in the stomach wall which is encircled by a pursestring suture of 000 silk The stomach should be attached to the peritoneum of the anterior abdominal wall with two or three sutures of the same material The incision is closed about the gastrostomy catheter with 000 chromic catgut


Trachea
Upper esoph
Vagus n
Azygos v
Parietal pleura and underlying lung
Hypoplasia of Lower esoph.
A
B


Upper esophagus
Cut edge of visceral perit
Stomach
Cardia
Diaphragm
Inferior Vena C.
Phrenic n.
C
D
Upper esoph
Cut edge of parietal pl
Pleural graft
Cardia
L gastric a ligated
Stomach
Diaphragm
Inf VC
Phrenic N.
Lung
E

CONGENITAL ATRESIA OF THE ESOPHAGUS WITH HYPOPLASIA OF THE LOWER ESOPHAGEAL SEGMENT

A The incision for the extrapleural exposure of the mediastinum is depicted by the solid curvilinear line For this exposure a seg ment of only one rib (fourth) is removed. The dotted line indicates the direction of the extension of the skin incision which was required in this patient when the extra pleural approach was converted into a transpleural one

B. A self retaining rib spreader (Tuffier) is inserted, and the extrapleural exposure of the mediastinum from the right side is shown The dilated upper segment and the hypoplastic lower segment of the esopha gus and their related structures are demon strable The azygos vein is doubly ligated and severed The light and heavy dotted *lines indicate the site of the incision through* the parietal pleura and the line of exten sion of the skin incision respectively

C. The right pleural cavity is entered and the avulsion laceration of the hypoplastic lower segment of the esophagus at the cardia which occurred when clamp traction was applied to mobilize the stomach into the pleural cavity is visible.

D The left gastric vessels are clamped, sev ered, and ligated, and the proximal portion of the stomach is mobilized with the aid of traction sutures of silk (000) into the right pleural cavity During this mobilization the cardia and not the fundus was uppermost. Despite the extent of the intrathoracic mo- bilization of the stomach, the spleen was not seen. The dotted line in the upper seg- ment of the esophagus indicates the site of the incision into its lumen for the anasto- mosis with the cardia of the stomach

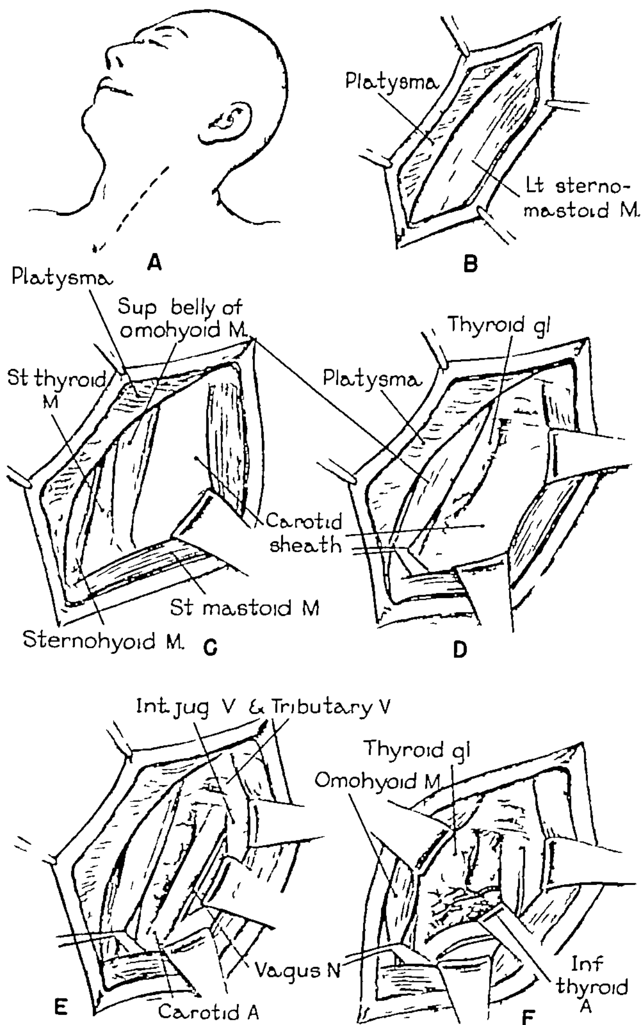
E. The cardia is mobilized into the apex of the right pleural cavity and the end to-end *esophagocardiostomy is completed* The area surrounding the anastomosis is en closed by a rectangular shaped free graft of parietal pleura to lessen the incidence of leakage at the suture line Closure of the chest wall and water seal catheter (14F) drainage of the pleural cavity completes the operation.

DISCUSSION—DRS. JOHN M BEAL AND CRANSTON W HOLMAN The difficulties associated with this uncom- mon anomaly are much greater than with the type in which tracheoesophageal fistula is present. If a pri- mary anastomosis is to be accomplished, as illus- trated by the author the stomach must be freely mo- bilized and brought into the chest This procedure is followed by a higher mortality rate than that follow ing an end-to-end anastomosis of the esophagus.

The postoperative course is complicated by fre- quent episodes of distention of the stomach trans- planted into the right pleural cavity which causes compression of the lung and consequent pulmonary problems. Frequent regurgitation of gastric contents also complicates the postoperative management of the infant. These difficulties have influenced some surgeons to do a multistage operation consisting of a cervical esophagostomy and a gastrostomy with later restoration of gastrointestinal continuity by transplantation and interposition of the right colon. However this particular type of anomaly is still a real challenge to the surgeon.

DISCUSSION—DR. CAMERON HAIGHT Incomplete development of the lower segment of the esophagus occurs in slightly more than 10 per cent of infants with esophageal atresia. As there is no fistulous communication between the trachea and the lower portion of the esophagus, the diagnosis of this type *of anomaly can be made by the absence of gas in* the stomach and intestines.

Although the operations employing intratho- racic mobilization of the stomach, as recommended in the text, have been successfully performed in newborn infants, the mortality following these pro- cedures is greater than that following the use of a multiple-stage plan The generally accepted method of treating this anomaly therefore, is by the use of a gastrostomy and cervical esophagostomy as the initial procedures. Later after an interval of about two or more years, continuity is established, usu- ally *by the retrosternal interposition of a segment* of colon between the cervical esophagus and stom- ach With the use of the multiple-stage plan the operative mortality is very low and the late re sults to date have been excellent.


A
Platysma
Lt sterno-
mastoid M
B
Platysma
Sup belly of
omohyoid M
St thyroid
M
Carotid
sheath
St mastoid M
Sternohyoid M
C
Thyroid gl
Platysma
D
Int jug V & Tributary V
Thyroid gl
Omohyoid M
Vagus N
Inf
thyroid
A
Carotid A
E
F

RESECTION OF PHARYNGOESOPHAGEAL DIVERTICULUM

Diverticula of the esophagus are classified into two types traction and pulsion. Traction diverticula most commonly occur on the anterior wall of the midportion of the thoracic esophagus in the region of the tracheal bifurcation. These diverticula are secondary manifestations of a surrounding inflammatory reaction and are true diverticula in that they contain all of the coats of the esophagus. However this type of esophageal diverticulum is of little surgical significance

The pulsion types of diverticula are most commonly found in the cervical region at the pharyngoesophageal level. They most commonly protrude on the left side, but they may be bilateral or protrude in the midline posteriorly They may occur infrequently in the lower third of the esophagus just above the diaphragm, the so-called epiphrenic diverticula, and protrude either toward the right or the left side in the posterior mediastinum. The pulsion type of diverticulum is classified as false in that the mucosa of the esophagus herniates through the layers of overlying muscle fibers and, accordingly the diverticulum does not consist of the whole thickness of the wall of the esophagus. In the cervical region this protrusion usually occurs in the space between the lowermost fibers of the inferior constrictor muscle of the pharynx and the fibers of the cricopharyngeus muscle. Occasionally the protrusion may occur through the uppermost fibers of the cricopharyngeus muscle.

Pulsion diverticula are more commonly found in males (4 1) and occur most frequently in the sixth and seventh decades However in the illustrated technic the drawings were *from sketches made by the artist while observing the operation performed in a 30-year-old* man who had symptoms of progressive dysphagia of 14 months duration.

A. The patient is anesthetized, using intratracheal anesthesia. The oblique linear incision employed, paralleling the anterior border of the sternomastoid muscle is depicted in dotted outline Rarely a right-side approach may be indicated for the exposure and the removal of a pharyngoesophageal diverticulum

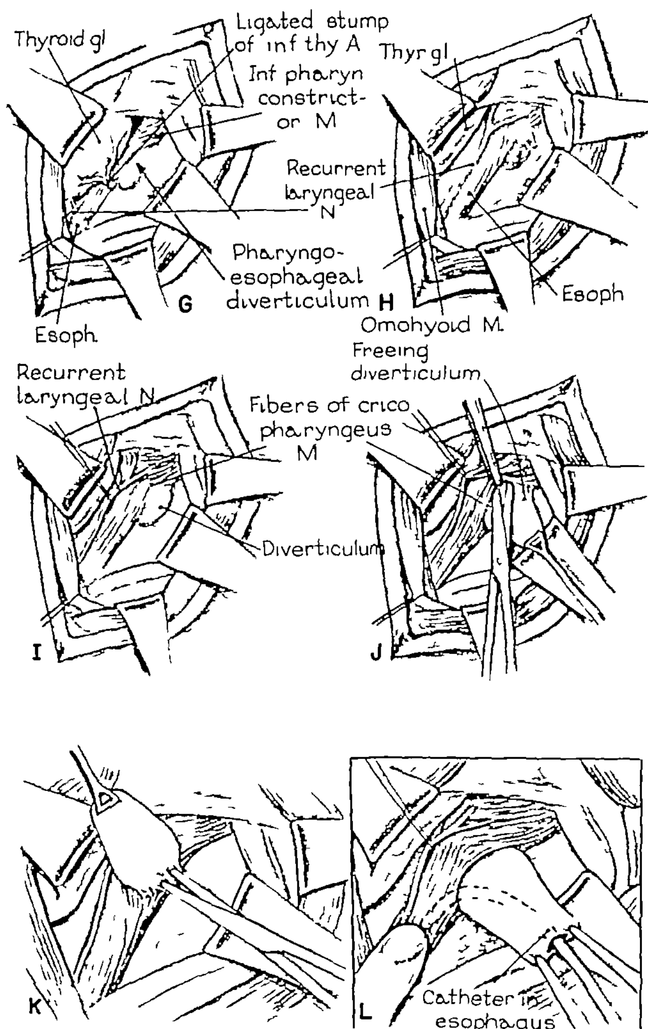
B. The incision is deepened through the platysma muscle and the anterior or investing layer of the deep cervical fascia to expose the fibers of the left sternomastoid muscle

C. The anterior border of the sternomastoid muscle is mobilized and retracted laterally to expose the middle or pretracheal layer of the deep cervical fascia and its contained carotid sheath The adjacent muscle structures are depicted.

D The tendinous pulley uniting the superior and inferior bellies of the omohyoid muscle is elevated by a guy suture of silk (0) and retracted downward and medially Severance of this tendon may be performed but this is generally not necessary The retraction of the superior belly of the omohyoid muscle medially exposes the posterolateral portion of the left lobe of the thyroid gland and its overlying fascial (pretracheal) covering

E. The middle or pretracheal fascial layer of the deep cervical fascia is incised to expose clearly the thyroid gland and the contents of the carotid sheath the internal jugular vein, the vagus nerve, and the common carotid artery In this patient there was an unusually large tributary vein as depicted which entered the internal jugular vein in the region conforming with the site of drainage of the common facial vein. Although it was in close approximation to the operative area, ligation and severance of this vein was not required.

F The superior belly of the omohyoid muscle and the underlying sternothyroid muscle are retracted anteriorly and medially and the sternomastoid muscle and the structures contained in the carotid sheath are retracted posteriorly and laterally to expose more clearly the posterolateral aspect of the left lobe of the thyroid gland. The inferior thyroid artery a branch of the thyrocervical trunk of the subclavian artery crosses horizontally beneath the carotid artery and divides into ascending and descending branches prior to its entrance into the gland structure The inferior thyroid artery is a useful landmark for the identification of a pharyngoesophageal diverticulum which is usually located immediately subjacent to this vessel.


Thyroid gl
Ligated stump of inf thy A
Inf pharyn constrict-or M
Thyr gl
Recurrent laryngeal N
Pharyngo-esophageal diverticulum
G
H
Esoph
Esoph.
Omohyoid M.
Freeing diverticulum
Recurrent laryngeal N.
Fibers of crico pharyngeus M
Diverticulum
I
J
K
L
Catheter in esophagus

G H The inferior thyroid artery is doubly ligated and severed (G) and the thyroid gland is retracted medially to expose the esophagus the diverticulum, and the recurrent laryngeal nerve (H)

I The recurrent laryngeal nerve, encircled by a guy suture of silk (000), bifurcated just prior to its passage beneath the lowermost fibers of the inferior constrictor muscle and its entrance into the larynx The identification and isolation of this nerve is important in the prevention of injury to it during the operative procedure. The diverticulum, covered by fibroareolar tissue, may be seen to protrude through the space between the lower border of the inferior constrictor muscle of the pharynx above and the fibers of the cricopharyngeus muscle below In some instances the protrusion may occur through the uppermost fibers of the cricopharyngeus muscle.

J K. A Babcock clamp is applied to the fundus of the partially mobilized diverticulum (J), and, with traction maintained through the clamp, the mobilization of the diverticulum from the surrounding structures is completed by scissor dissection (K).

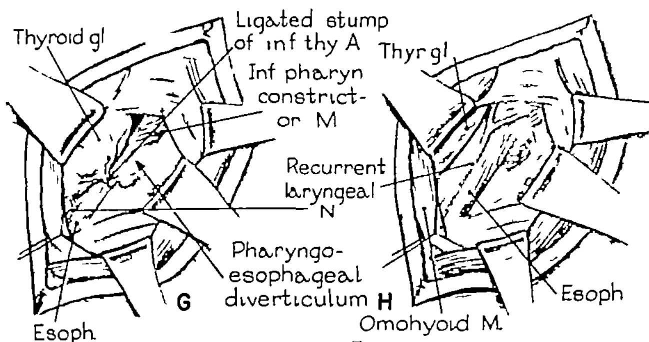
L. Inset showing a magnified view of the completely mobilized diverticulum and the demonstration of a technic for the determination of the level of the true neck of the diverticulum In this particular patient the neck of the diverticulum appeared unduly wide in diameter Accordingly a catheter (16 F) was inserted through an opening in the fundus of the diverticulum and into the lumen of the distal portion of the esophagus where its tip could be readily palpated by the left index finger impinged against the outer wall of the esophagus In this manner the true neck of the diverticulum was defined and the line for the resection indicated

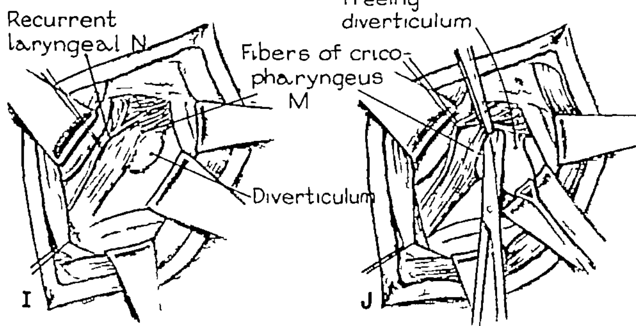
DISCUSSION—DR. KENNETH W WARREN. It has been an almost invariable practice at the Lahey Clinic to employ a long, oblique incision along the anterior border of the left sternomastoid muscle in approaching pharyngoesophageal diverticula. The choice of this type of incision is based upon the observation that one cannot prophesy preoperatively which diverticulum will be easily exposed, delivered, and dissected and which—because of its size, its adherence to the esophagus or related cervical structures—will prove to be difficult to manage Until recently the majority of pharyngoesophageal diverticula treated at the Lahey Clinic were removed by the two stage operation The long, oblique incision placed along the sternomastoid muscle afforded ample opportunity in this two stage procedure to permit fixation of the fundus of the diverticulum high in the cervical region so that the most dependent portion of the diverticulum would be at the junction of the sac with the longitudinal esophagus Over 90 per cent of esophageal diverticula currently treated at the clinic are excised in a one stage maneuver We still prefer this incision

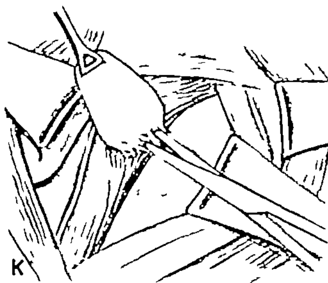
The skin and platysma are incised, and the anterior edge of the sternomastoid muscle on the left is reflected laterally thus exposing the anterior belly of the omohyoid muscle We have preferred to remove the anterior segment of this muscle completely rather than to retract it as is demonstrated in Plate 45 (D) The advantages of removing this segment of the omohyoid (while it is not necessary in every instance) are very great. This maneuver exposes the internal jugular vein with its branches running to the thyroid gland. After division of these lateral thyroid veins, the left lobe of the thyroid is elevated and rotated anteriorly and medially thus exposing the common carotid artery which is then retracted laterally Retraction of the carotid artery affords access to the inferior thyroid artery which is then divided between clamps and ligated. This division permits a greater degree of mobility of the left lobe of the thyroid. The left recurrent laryngeal nerve is then identified and its entire cervical course is exposed, but manipulation of this structure is avoided insofar as possible.

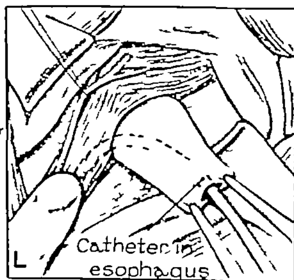
The preceding maneuvers expose the region of the pharyngoesophageal diverticulum which can now be identified. The fundus of the sac is grasped with Babcock forceps and the junction between the inner edge of the sac and the longitudinal esophagus is demonstrated In some instances, the sac will be enveloped by a considerable thickness of fibers of the cricopharyngei which may make its identification difficult. In other instances, the sac may be extremely large and extend well down into the mediastinum. The delivery of such a large diverticulum from the mediastinum must be done with great care lest the diverticulum be perforated during this maneuver

It should be borne in mind that the pharyngoesophageal diverticulum prior to its dissection lies


Thyroid gl
Ligated stump of inf thy A
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Recurrent laryngeal N
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Diverticulum
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Freeing diverticulum
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K


Catheter in esophagus
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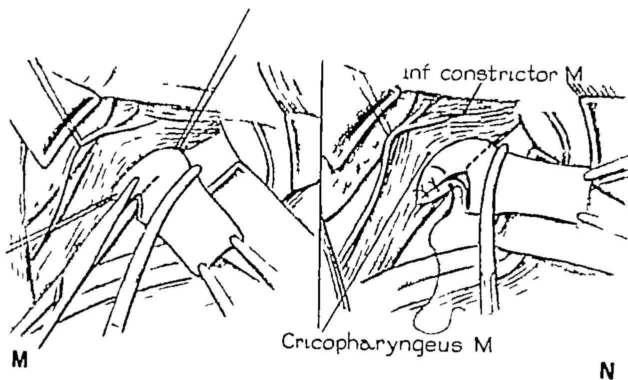
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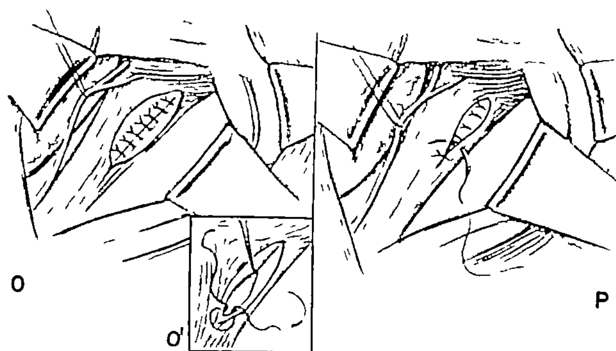
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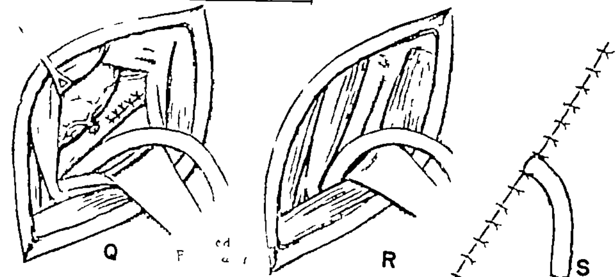
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inf constrictor M
Cricopharyngeus M
M
N


O
O'
P


Q
R
S

M N Traction guy sutures of silk (000) are inserted through the neck of the diverticulum at its upper and lower borders, and the diverticulum is cross-clamped distally The excision is begun by scissor dissection (M) and, following a partial resection the cut margins of the mucosa and the submucosa layers of the esophagus are approximated with interrupted sutures of silk (000) In excising the diverticulum, excessive traction on its distal portion should be avoided. Otherwise, the walls of the esophagus may be tented into the line of resection with resulting constriction of the esophageal lumen.

O The excision of the pharyngoesophageal diverticulum is completed, and the opening in the esophagus is closed with a series of interrupted sutures of silk (000).

O Inset to show an alternate method for the closure of the opening into the lumen of the esophagus. The interrupted sutures of silk (000) are inserted from the "inside out" to the "outside in" so that, when tied, the knots of the sutures are on the inside of the lumen

P Q The defect in the musculature through which the diverticulum protruded is closed with interrupted sutures of 000 silk (P), and a Penrose (cigarette) drain is inserted into the cervical mediastinal space (Q).

R. The left sternomastoid muscle is gently retracted to show the relation of the surrounding muscles, previously labeled, to the carotid sheath and the site of drainage The large tributary of the internal jugular vein previously mentioned is visible in the upper angle of the wound.

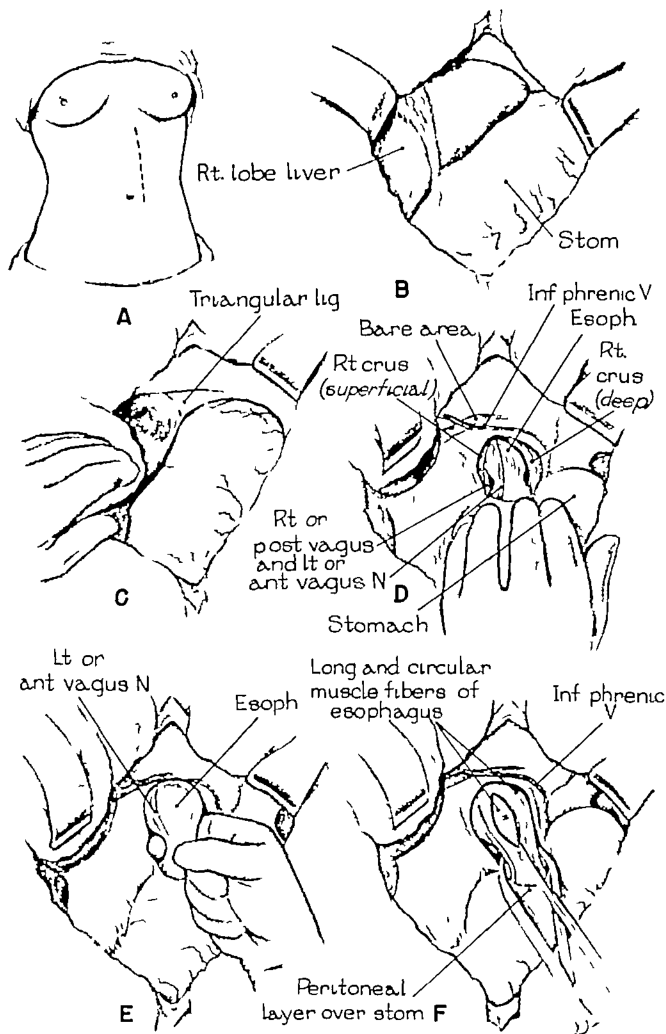
S. The operation is completed by closure of the skin incision about the drain, using interrupted sutures of silk (000)

DISCUSSION—DR. WARREN (cont.)

parallel to the longitudinal esophagus and that as the dissection of the sac from the esophagus is carried out, an acute angle is made by the junction of the neck of the sac with the longitudinal esophagus. If recurrence of the diverticulum is to be avoided, it is extremely important to dissect the neck of the sac completely It is easy to misjudge the degree of thoroughness of the dissection at this point, for the neck of the sac will be completely covered by an investment of the muscle fibers of the cricopharyngeus even though the sac has been liberated so that it hangs by its neck. We have always made it a point to dissect the neck of the sac until the pale white fibers of the submucosa of the sac are clearly visible. This dissection is relatively easily achieved in the inferior superior and left lateral positions. Unfortunately dissection of the right side of the neck is more difficult since the fixed position of the cricoid cartilage and of the pharynx makes it impossible to rotate the posterior wall of the pharynx sufficiently to see the right lateral wall of the sac directly except in those instances in which the diverticulum is very small and the neck quite narrow If this phase of the dissection is done with care and with appreciation of the anatomic relationships and of the embryology of these diverticula, there will be no difficulty in determining the site of the junction of the diverticulum with the longitudinal esophagus

When the sac has been thoroughly mobilized as previously described, one must decide how to deal with the neck of the sac If the diverticulum is small or only moderately large and the neck is narrow it is reasonable to ligate the neck of the sac flush with its junction with the longitudinal esophagus, using a 00 chromic catgut ligature. A clamp is then placed distal to this ligature and the sac is amputated, leaving an adequate amount of stump to insure that it will not retract through the previously placed ligature. When the neck of the sac is broad, it is best to divide its neck slightly distal to its precise junction with the longitudinal esophagus, and to close the defect with a continuous Connell inverting suture of fine catgut reinforced by a row of interrupted sutures of the same material It is quite permissible to close this defect with interrupted sutures but we prefer to use inverting sutures, even though they be interrupted. After amputation of the sac and closure of the esophagus either by ligature or by the inversion suture method, it is important to approximate the cricopharyngel muscles over the closed neck of the sac We usually employ a cigarette drain and bring it out in the lower angle of the incision

This comment has been limited to the one stage procedure. However it is well to remember that the two stage procedure still has merit in the presence of the large pulsion diverticulum of the pharyngoesophagus when the sac extends well down into the mediastinum and when diverticulitis and peridiverticulitis are prominent features. The two stage procedure should also have considerable appeal to those surgeons with a limited experience in esophageal surgery who, nevertheless undertake to operate on pharyngoesophageal diverticula


A
Rt. lobe liver
Stom
B
Triangular lig
Inf phrenic V
Esoph
Bare area
Rt crus
(superficial)
Rt.
crus
(deep)
C
Rt or
post vagus
and lt or
ant vagus N
D
Stomach
Lt or
ant vagus N
Esoph
Long and circular
muscle fibers of
esophagus
Inf phrenic
V
Peritoneal
layer over stom
E
F

ESOPHAGOCARDIOMYOTOMY—TRANSABDOMINAL APPROACH

A B. The peritoneal cavity is entered through an upper left rectus muscle splitting or muscle retracting incision (A) and the underlying intraperitoneal viscera are demonstrable (B).

C By manual retraction overlying a protective moist gauze pad the peritoneal attachment forming the left triangular ligament of the liver is made taut and severed as indicated by the dotted line

D The mobilized left lobe of the liver covered by a moist gauze pad, is folded downward on itself and retracted medially to expose the opening in the peritoneal fascial layer overlying the esophagocardial junction. The lower end of the esophagus, the vagus nerves, and the esophageal hiatal ring formed by the superficial and deep muscle bundles of the right crus are visible The tapered and thinned out terminal portion of the esophagus and the dilatation proximally characteristic findings in achalasia may also be seen

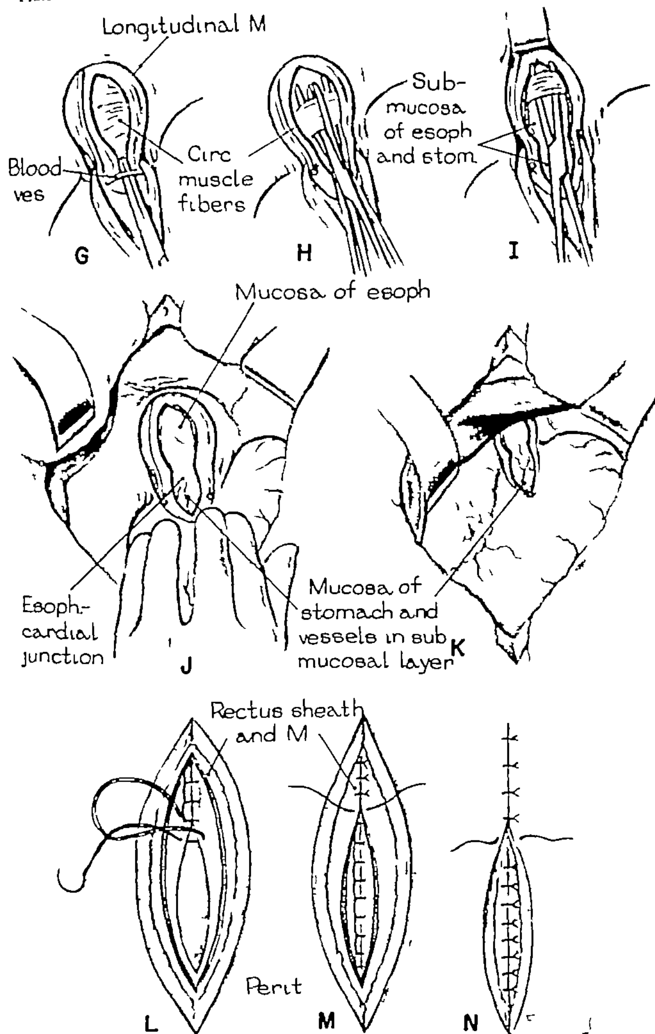
E. By careful digital manipulation within the posterior mediastinum, the lower portion of the esophagus is mobilized and displaced downward into the peritoneal cavity

F The esophagus at the level of the esophagocardial junction is encircled by a tape of rubber tissue and with downward traction maintained, a linear incision through the fibers of the longitudinal muscle layer of the esophagus and the adjoining segment of the stomach is begun

DISCUSSION—DR. RICHARD H. SWEET The operation of esophagomyotomy may be performed either through an abdominal incision, as originally advocated by Heller or through a left thoracotomy incision. In my opinion the latter is preferable for the following reasons. (1) The incision through the left eighth intercostal space can be easily and quickly made and closed. (2) The exposure of the lower esophagus is more easily obtained, and access to the entire length of the lower segment is secured without dissection and mobilization which must always be employed when the abdominal approach is used This makes it easier to avoid the vagus nerves and to minimize the amount of trauma in the lower esophageal region (3) The fascial layers in the esophageal hiatus of the diaphragm are not greatly disturbed. (4) It is simple, using this approach, to repair a coexisting hiatus hernia with a minimum of dissection.

A technical matter which may make the difference between success and failure in the use of this operation for the treatment of megaesophagus is the length of the myotomy incision. As shown in Plate 48 (F) this incision must extend upward on the esophagus to a point where the diameter of the organ is large. It is not necessary on the other hand, to extend the incision onto the wall of the stomach below the cardia. No hypertrophied circular muscle fibers are ever found distal to this point. It must be remembered that the abnormality is in the esophagus. The unnecessary extension of the incision into the stomach wall below the cardia usually is harmless, but because the muscular layers there are thin, it is easy to penetrate the mucosal layer If this accident should occur a careful closure of the opening should be made with sutures of fine silk.

The dissection between the circular muscle layer and the submucosa as shown in Plate 49 (H and I) is unnecessary and might even be harmful. It is much easier and safer merely to cut through the muscle layers with a sharp knife. It is absolutely essential, however to divide every single circular muscle fiber in order to avoid leaving a stenotic point Plate 49 (J) shows the appearance of the bulging mucosal layer when the division of the muscle has been completely accomplished, although in my opinion the incision as illustrated extends unnecessarily far into the wall of the stomach.


Longitudinal M
Blood ves
Circ muscle fibers
Sub-mucosa of esoph and stom
G
H
I
Mucosa of esoph
Esoph-cardial junction
J
Mucosa of stomach and vessels in sub mucosal layer
K
Rectus sheath and M
Perit
L
M
N

G The incision through the longitudinal muscle layer of the esophagus is completed, and the underlying layer of circular muscle fibers is visible A vessel crossing transversely at the level of the cardia is shown elevated on a clamp prior to its double ligation and severance.

H, I. Following the completion of the incision in the longitudinal muscle layers of the esophagus, the cardia, and the segment of the gastric wall immediately below the cardia, the underlying circular layers of muscle fibers are elevated in segments and severed by scissor dissection

J K. The esophagocardiomyotomy is completed and the herniation of portions of the mucosa of the esophagus the cardia, and the adjacent segment of the stomach respectively are depicted. The prominence of the vessels in the submucosal layer of the stomach may also be seen

L, M N The wound is closed in layers using a double strand of a continuous interlocking suture of 00 chromic catgut for the peritoneum (L) interrupted sutures of 00 silk for the fascia (M), and 000 silk for the skin (N)

Discussion—Dr. Mark M Ravitch In many patients an oblique subcostal incision provides easy access to the esophageal hiatus. The rectus-splitting incision invariably paralyzes the portion of the rectus muscle medial to it and does not provide significantly better exposure than the rectus-retracting incision. For most gastric operations, unless the patient has a very flat costal arch, the midline incision, through the linea alba is satisfactory and is technically the simplest. As emphasized in G through K the esophagogastric incision is a long one extending 5 cm up on the esophagus and 5 cm. down on the stomach through to the submucosa. Wangensteen suggested the passage of a balloon into the esophagus to distend it and to render this phase of the operation simpler

It will be seen in D E, and F that there is considerable dissection within the hiatus, and this may result in the appearance of a postoperative hiatus hernia. It is probable that a certain proportion of the unsatisfactory results following Heller's cardiomyotomy are, in fact, due to the operative creation of a hiatus hernia For this reason it is wise always to place one or two sutures behind the esophagus, approximating the fibers of the right crus, as in the repair of a hiatus hernia from the abdominal approach. In order further to prevent regurgitation into the esophagus and subsequent esophagitis, the bane of most other procedures for achalasia, Lortat Jacob has emphasized the wisdom of tacking the gastric fundus up to the esophagus in order to re-create the angle of His and introduce what is almost a valvular mechanism at the esophagogastric junction, like the one produced by the normally acute angle of insertion of the esophagus into the stomach.

Discussion—Dr. C Rollins Hanlon I prefer an upper midline approach for this type of subdiaphragmatic exposure A transverse epigastric incision dividing both rectus muscles may be adequate in patients with flaring costal margins

Neither of these abdominal incisions provides full access to the esophagus for an upward extension of the myotomy which is, at times, desirable Conversely it is easy to overextend the gastric portion of the muscle division, which may destroy the subdiaphragmatic portion of the esophageal sphincter This destruction is conducive to reflux and, at times, to esophagitis.

The ability to explore the abdomen is an obvious advantage of the transabdominal approach but does not seem to be a dominant consideration.

INT MAMMARY VESSELS

PERICARDIUM

PHRENIC N

INF PUL LIG

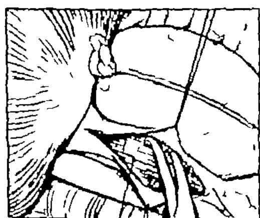
DIAPHRAGM

AORTA

LT LOWER LOBE

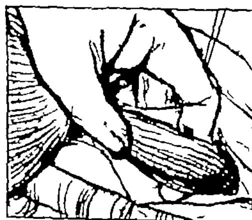
A

B



C

ESOPHAGUS



D

ESOPHAGOCARDIOMYOTOMY—TRANSTHORACIC APPROACH

A. The patient is placed in the direct right lateral prone position. The incision overlying the eighth rib is indicated by the broken line

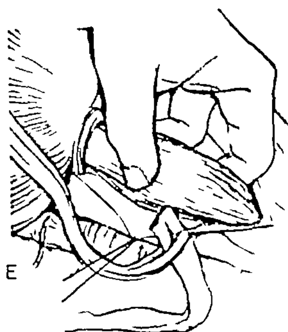
B. The left pleural cavity is entered through the eighth intercostal space (Brock technic) and the related intrapleural structures are depicted. The lower lobe of the left lung, partly visible, is covered by a moist gauze pad and retracted cephalad. Sutures of 000 silk are inserted in the inferior pulmonary ligament, which is subsequently incised between the ligatures.

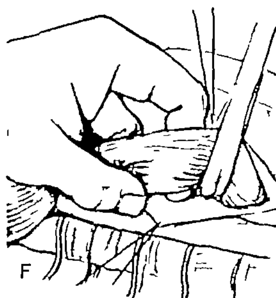
C. The incised margins of the inferior pulmonary ligament are retracted by sutures (000 silk) and the areolar tissue attachments about the esophagus are freed by scissor dissection.

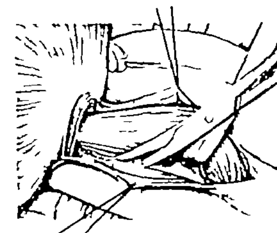
D. The lower portion of the dilated esophagus is mobilized by blunt digital dissection from its "bed" in the posterior mediastinum.

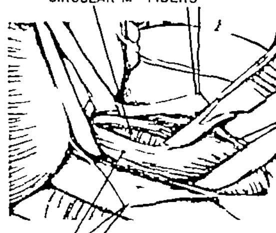
DISCUSSION—DR. MARK M. RAVITCH. Ordinarily patients with achalasia who require operation have lost sufficient weight so that there is no difficulty in dissecting about the cardia through the transabdominal approach. It is easier and does less violence to the hiatus, to bring the esophagus into the peritoneal cavity from below than to bring the stomach up into the thoracic cavity from above. In either case, it is mandatory to make the esophagogastric incision a long one, and just as long (5 cm.) on the gastric side as on the esophageal side of the esophagogastric junction.

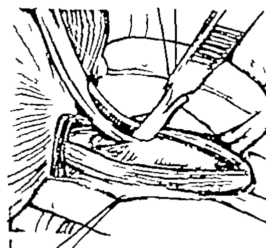
Heller originally advised two incisions, one anterior and one posterior. This would make assurance doubly sure but does not appear to be necessary. Whether the operation is done from above or from below the hiatus should be reinforced at the conclusion of the esophagocardiomyotomy. Tacking the fundus to the side of the esophagus is as feasible in the transthoracic as in the transabdominal approach.

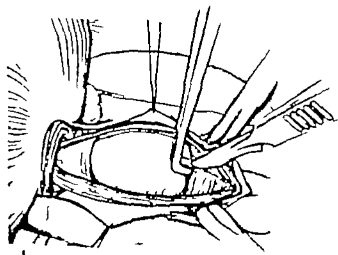

E


F


G


CIRCULAR M FIBERS
H
LONGITUDINAL M FIBERS


I


J

E, F G. A rubber-tissue tape is inserted beneath the esophagus (E) to encircle it (F) and as traction on the tape is maintained, the esophagus is mobilized by scissor dissection of its areolar tissue attachments (G) The right or posterior vagus nerve in relation to the partly mobilized esophagus is visible (G)

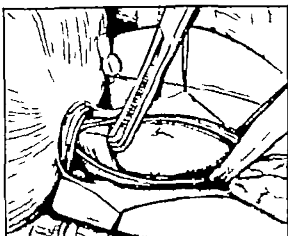
H. A second rubber tissue tape encircles the esophagus caudad, and as traction is maintained on the tapes, the longitudinal or outer layer of muscle fibers in the lower portion of the esophagus is incised Through the incision some of the fibers of the underlying circular muscle layers may be seen.

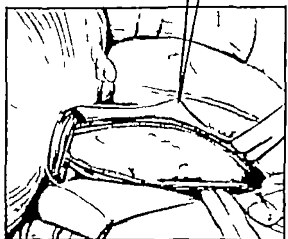
I. The incision in the outer (longitudinal) muscle layer is completed, and the inner (circular) muscle layer elevated on a curved (Kelly) clamp is incised

J The circular muscle layer cephalad is similarly elevated on a Mixter clamp, and the severance of its fibers is completed (broken line)

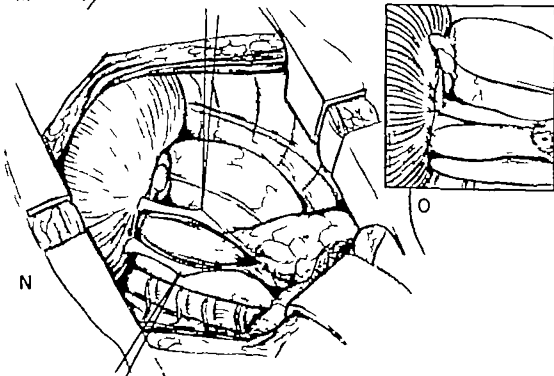
Discussion—Dr. C Rollins Hanlon It seems clear that esophagocardiomyotomy omitting the posterior of the two incisions advocated by Heller is the best treatment for achalasia of the esophagus I prefer a transthoracic approach, despite the occasional occurrence of annoying intercostal neuralgia after this procedure. Satisfactory access may be obtained by excision of the seventh, eighth, or ninth rib entry through the eighth intercostal space gives adequate exposure

The technic portrayed in illustrations B through G is quite satisfactory Particular care should be taken not to damage either vagus nerve, because vagotomy tends to aggravate the dysfunction In contrast to use of the knife in H I use Metzenbaum scissors to divide both layers of muscle, thus minimizing the likelihood of mucosal perforation, especially at the important lower end of the dissection. The incision is usually 10 cm long and extends over the stomach only far enough to insure complete division of all circular esophageal muscle fibers. Excessive prolongation of the incision on the stomach or damage to the right crus may explain some cases of late, regurgitant esopha-


K


L


LEFT MARGIN OF
RIGHT CRUS
CUT EDGE OF
MUSCLE
RIGHT MARGIN OF
RIGHT CRUS
M


O
N

K. The fibers of the remaining and caudad segment of the circular muscle layer are transected as indicated (broken line)

L. The esophagocardiomyotomy is completed, and the herniation of the mucosal layer of the esophagus is visible. The relation of the incised margins of the muscle layers of the esophagus to the muscle fibers of the right crus of the diaphragm which form the esophageal hiatal ring is also visible

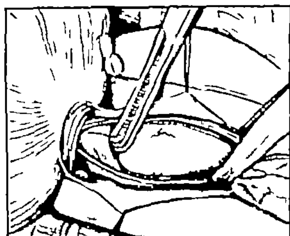
M. A close-up view shows more clearly the relation of the lower portion of the esophagus to its hiatal ring. A segment of the right (posterior) vagus nerve is also seen.

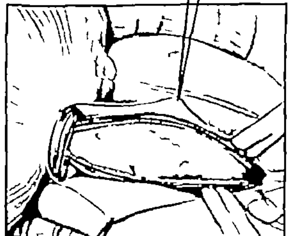
N O The operative field before (N) and after (O) approximation of the pleural leaflets overlying the diaphragm is shown. The mediastinal pleural leaflets are not sutured. Expansion of the lung and closure of the thoracic incision complete the operation. A waterseal drainage catheter (18 F) is used during the closure of the wound and may be removed as the final skin suture is being tied about it.

DISCUSSION—DR. HANLON (cont.)

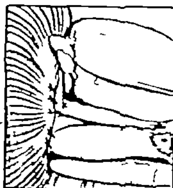
gus. If hiatus hernia is present or is rendered likely by the dissection, a few sutures may be placed for approximation of the fibers of the right crus posteriorly

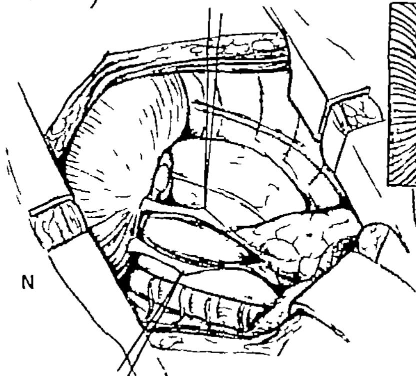
The mucosa should bulge over a wide area, as shown in L. Passage of a sound or easy inflation of a pneumatic dilator (60 F) by the anesthesiologist assures one that the size of the cardia is adequate. In addition, it may demonstrate persistent circular muscle fibers requiring division. Though some have advocated retrograde passage of the fingers or a balloon dilator through a gastrotomy this seems unnecessarily complex and increases the risk of infection in the pleural space. With an incidence of mucosal perforation in the vicinity of 10 per cent, it seems safer to leave an intercostal water seal drainage catheter in place for a day or two, especially if a recognized perforation has been sutured.


K


L


LEFT MARGIN OF
RIGHT CRUS
RIGHT MARGIN OF
RIGHT CRUS
CUT EDGE OF
MUSCLE
M


O


N

K. The fibers of the remaining and caudad segment of the circular muscle layer are transected as indicated (broken line)

L. The esophagocardiomyotomy is completed, and the herniation of the mucosal layer of the esophagus is visible The relation of the incised margins of the muscle layers of the esophagus to the muscle fibers of the right crus of the diaphragm which form the esophageal hiatal ring is also visible

M. A close-up view shows more clearly the relation of the lower portion of the esophagus to its hiatal ring. A segment of the right (posterior) vagus nerve is also seen.

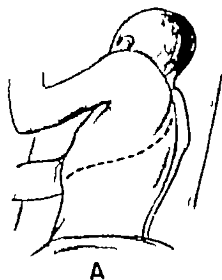
N O The operative field before (N) and after (O) approximation of the pleural leaflets overlying the diaphragm is shown. The mediastinal pleural leaflets are not sutured. Expansion of the lung and closure of the thoracic incision complete the operation. A waterseal drainage catheter (18 F) is used during the closure of the wound and may be removed as the final skin suture is being tied about it.

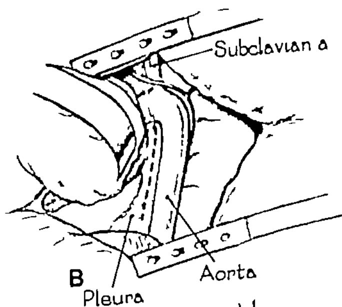
DISCUSSION—DR. HANLON (cont.)

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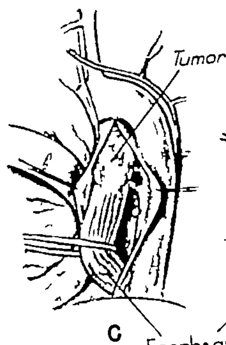
The mucosa should bulge over a wide area, as shown in L. Passage of a sound or easy inflation of a pneumatic dilator (60 F) by the anesthesiologist assures one that the size of the cardia is adequate In addition, it may demonstrate persistent circular muscle fibers requiring division. Though some have advocated retrograde passage of the fingers or a balloon dilator through a gastrotomy this seems unnecessarily complex and increases the risk of infection in the pleural space. With an incidence of mucosal perforation in the vicinity of 10 per cent, it seems safer to leave an intercostal water seal drainage catheter in place for a day or two especially if a recognized perforation has been sutured.

Plate 53

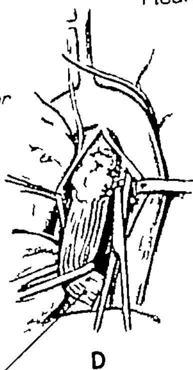

A

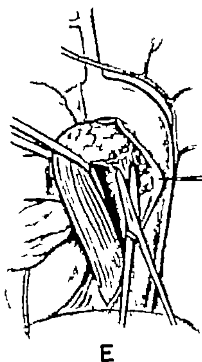


B

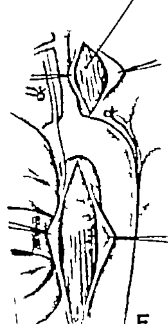


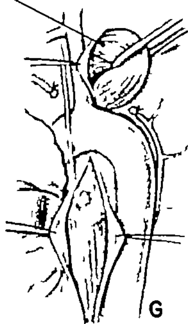
C

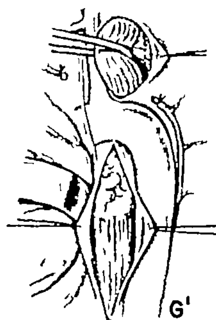

D


E

Esophagus


F


G


G'

ESOPHAGECTOMY LEFT TRANSPLEURAL TRANSDIAPHRAGMATIC APPROACH WITH SUPRAAORTIC AND INFRAAORTIC ESOPHAGOGASTROSTOMY

A. The patient is placed in the direct right lateral prone position and the left thoracotomy incision is shown in dotted outline. Although not shown the seventh rib is partially resected and segments (2 cm) of the vertebral ends of the sixth and eighth ribs are also removed The related intercostal neurovascular muscle bundles are clamped, severed, and ligated with suture ligatures of silk (00)

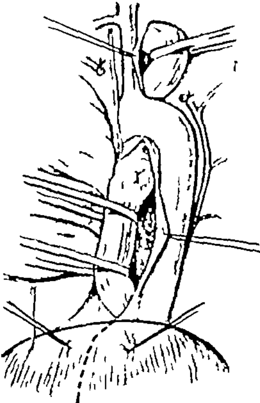
B. The left pleural cavity is entered and the rib cage is separated over protective moist towels with a self retaining retractor (Finochietto) The incision in the posterior mediastinal pleura is depicted by the dotted line

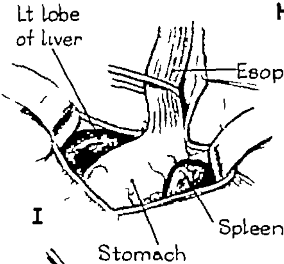
C. The cut margins of the mediastinal pleura are retracted with guy sutures (0000 silk) and the tumor of the esophagus is exposed. The lower portion of the esophagus, previously mobilized by blunt digital dissection, is encircled by a cotton tape for traction With traction maintained anteriorly and toward the midline the esophageal branches of the thoracic aorta are isolated, doubly ligated in continuity and then severed between the ligatures Usually two and at the most three arterial branches are ligated in the area between the arch of the aorta and the diaphragm

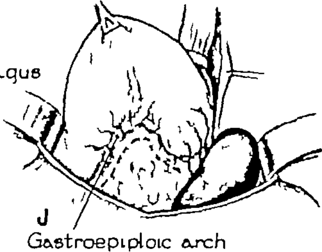
D, E. Dissection with scissors is continued in the fibroareolar tissue layer surrounding the tumor until it is completely mobilized from the surrounding structures. In the dissection at this level there is danger of injury to the azygos vein which is not visible and which may be adherent to the right side of the tumor bearing area of the esophagus.

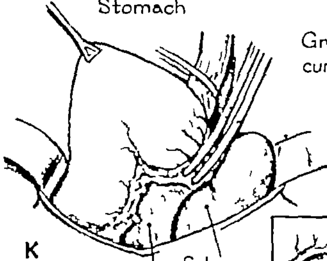
F The mediastinal pleura above the aortic arch and lateral to the subclavian artery is incised and the cut margins are secured with guy sutures of silk (0000)

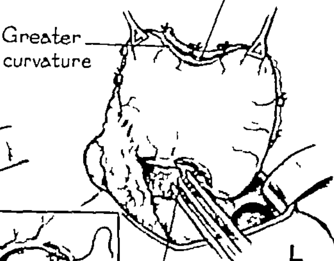
G G The supraaortic segment of the esophagus is encircled by a cotton tape and retracted in various planes as the surrounding fibroareolar tissue is severed (dotted lines) by scissor dissection In performing the dissection in this area the surgeon should be cognizant of the proximity of the lymphatic duct and the increased likelihood of its injury

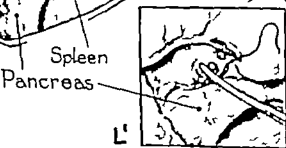

H


Lt lobe
of liver
Esophagus
I
Spleen
Stomach


J
Gastroepiploic arch


K
Spleen
Pancreas


Greater
curvature
L
Lt gastric a


L'

H. The supraaortic and infraaortic segments of the esophagus are encircled by cotton tapes through which traction is applied to elevate the esophagus and the tumor mass from the depths of the mediastinum Traction guy sutures of silk (00) are used to tent a portion of the left leaflet of the diaphragm which is incised in the direction indicated by the dotted line. This radial incision extends through the esophageal hiatal ring preparatory to the mobilization of the esophagocardial junction.

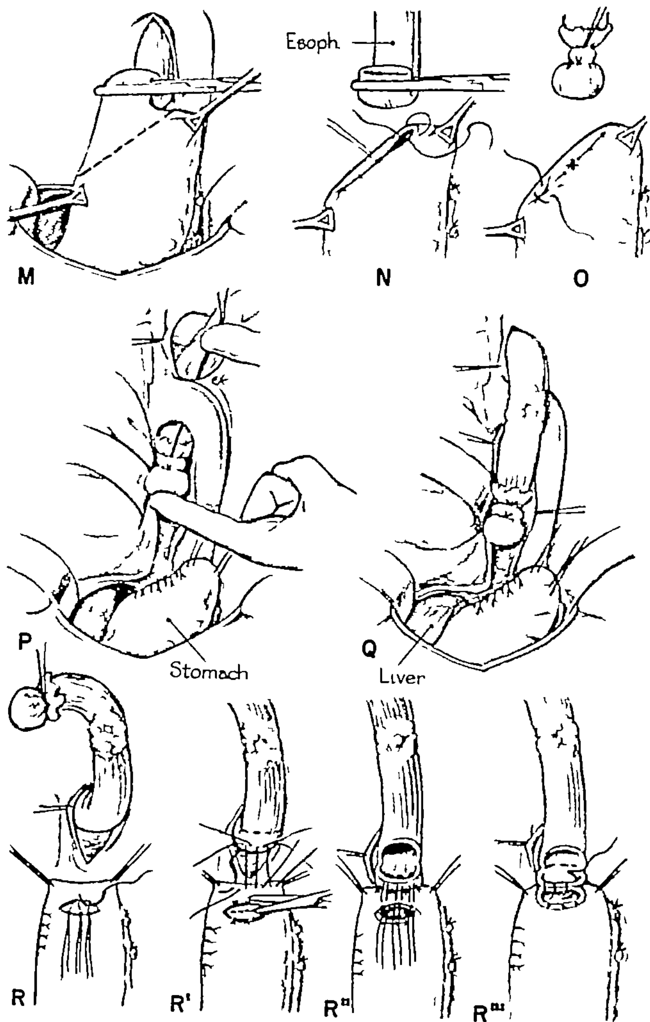
I The transdiaphragmatic incision is completed and the subjacent intraperitoneal viscera are demonstrated. This incision converts the left pleural and the subjacent peritoneal cavity into one common cavity

J The anterior wall of the stomach is grasped in a Babcock clamp through which traction is applied to displace the stomach upward into the left pleural cavity The severance of the gastrocolic ligament below the gastroepiploic arch is indicated in dotted out line.

K. The mobilization of the greater curvature of the stomach is continued by doubly clamping and severing (dotted line) the gastrosplenic ligament and its contained vasa brevia.

L. The completely mobilized greater curvature of the stomach is grasped in Babcock clamps and retracted anteriorly and cephalad to show the left gastric vessels, contained in the gastropancreatic fold of peritoneum, triply clamped prior to their severance between the two distal clamps

L The clamped and severed left gastric vessels are occluded proximally with a ligature of silk (00) and the lowermost clamp is removed. A second suture, a suture ligature of 00 silk, is inserted distally beneath the uppermost clamp which is removed as the suture is tied


Esoph.
M
N
O
P
Stomach
Q
Liver
R
R'
R''
R'''

M. The completely mobilized stomach anchored only by its esophageal and duodenal attachments, is secured proximally with Babcock clamps, and the line of transection of the stomach below the clamp-occluded esophagocardial junction is shown in dotted outline

N O The oblique opening in the proximal *segment of the stomach is closed with in*terrupted sutures of silk (000) The sutures are inserted from the "inside out" and from the "outside in" so that when tied the knots are on the inside of the lumen The reinforcing second layer of interrupted horizontal seromuscular mattress sutures (Cushing) are inserted to complete the closure of the transected stomach. The esophagogastric stump proximally (O) is covered by a piece of rubber dam and occluded with two ligatures of No 1 silk.

P Q The long strands of the proximal ligature which occludes the distal end of the esophagus are passed upward behind the aortic arch and by traction through these strands from above and digital manipulation from below (P) the tumor mass and the distal segment of the esophagus are displaced upward behind the arch of the aorta to a position anterior to the aortic arch (Q)

R. Traction sutures (000 silk) are inserted in the fundus of the stomach and immediately subjacent, a horizontal incision is made through the seromuscular layer of the stomach at the site of election for anastomosis to the esophagus. The vessels in the submucosal layer are undersewn with hemostatic suture ligatures of silk (0000). The performance, at this time, of this particular step in technic obviates troublesome bleeding when the opening into the lumen of the stomach is subsequently made (R'). The excision of a circular area of stomach *wall is neither* practiced nor recommended. A careful mucosa to mucosa approximation is considered the best prophylaxis for stenosis at the stomal site

R The first posterior layer of interrupted sutures are being inserted On the esophageal side the sutures are inserted at right angles to the fibers of the longitudinal muscle layer to increase the holding power of the tissues The dotted line on the posterior wall of the esophagus indicates its site of transection The opening into the lumen of the stomach is being enlarged by scissor dissection between the two rows of the previously inserted hemostatic ligatures which have been tied and cut.

R R A second posterior layer of interrupted and untied mattress sutures of silk (000) is inserted (R) these when tied (R '), effect an inversion of the tissue layers into the lumen of the anastomosis. A third posterior layer of interrupted sutures (000 silk) is inserted (R ') through the whole thickness of the inverted layers of the stomach and the esophagus.

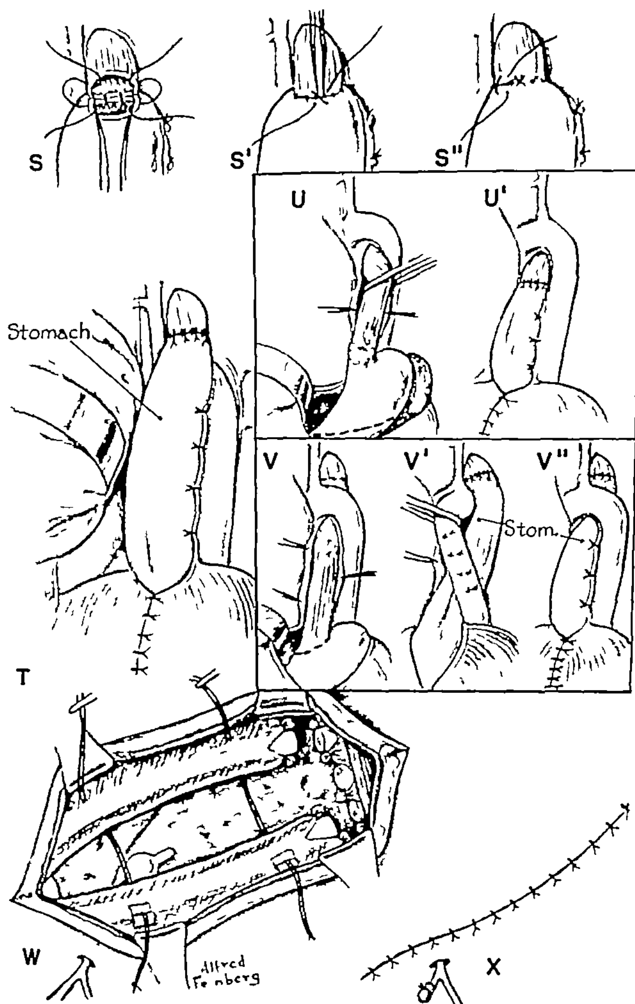
DISCUSSION—DR JOHN H GARLOCK For adequate exposure, I have found it necessary to remove only one rib usually the seventh, in most instances By opening the rib spreader slowly and in stages, it is possible to obtain adequate room without cracking, accidentally or purposely the ribs above or below In heavy chested men, it may be necessary to divide the sixth or eighth ribs or both, and this is done without disturbing the intercostal neurovascular bundles

I would suggest using soft Penrose tubing instead of cotton tape when mobilizing the esophagus Many patients with cancer of this organ exhibit friable musculature, and, unless the traction tape has considerable resiliency and "give," the organ may be torn at a site which is not to be excised If the surgeon limits his dissection close to the esophagus in the supra aortic area, he need have little fear of injuring the thoracic duct.

The use of grasping clamps, as depicted (Plate 54 K and L) is to be avoided for reasons stated previously The stomach can be easily and gently displaced above the opening in the diaphragm by the gloved hand.

When ligating the left gastric vessels, the surgeon should make every effort to clear this vascular pedicle of all lymph nodes. In more than 50 per cent of our cases, squamous cell cancers of the thoracic esophagus have metastasized retrogradely to the nodes along the left gastric artery

As stated before, I would suggest a wider excision


S
S'
S''
U
U'
Stomach
V
V'
V''
Stom.
T
W
X
Alfred
Feinberg

S. The first anterior layer of the anastomosis is begun by inserting the angle sutures which are inserted from the "inside out" on one side and from the "outside in" on the other side so that when tied the knots are on the inside of the lumen Traction on the long strands of the angle sutures posteriorly facilitates the inversion of the first anterior layer

S The interrupted inversion sutures are inserted alternately from either end toward the center at which juncture the first two sutures are encircled by a figure of 8 mattress suture before being cut.

S The mattress suture is tied and cut and the second anterior layer of the anastomosis, a series of interrupted horizontal mattress sutures (Cushing), is begun.

T The left supraaortic esophagogastrostomy is completed. The intrathoracic portion of the stomach is anchored with interrupted silk (000) sutures to the mediastinal pleura, and the incision in the diaphragm is closed snugly about the transplanted stomach with interrupted silk (00) sutures

U U Inset to show the extent of resection (U) and the completed infraaortic esophagogastrostomy (U′) for the surgical removal of a carcinoma in the region of the esophagocardial junction

V V V Inset to show an alternate method, used in one patient in the treatment of a carcinoma of the midthoracic segment of the esophagus (V) The thoracic aorta is completely mobilized by ligation and severance of the paired intercostal arteries and rotated anteriorly (V′) This permits the transplantation of the mobilized stomach into the esophageal bed within the mediastinum and the establishment of the esophagogastric anastomosis posterior and superior rather than anterior and superior to the arch of the aorta (V V′)

W A Foley catheter (18 F) is partially withdrawn through a stab wound drainage site in the eighth intercostal space and connected to a water seal drainage bottle. Periosteal "windows" are made in the eighth rib and two pericostal sutures of double strands of No 2 chromatic catgut are inserted to encircle the eighth and sixth ribs. When tied these sutures will approximate the rib cage about the partially resected seventh rib The partially resected segments (2 cm.) at the vertebral ends of the sixth and eighth ribs are also visible. The formation of periosteal "windows" is believed to lessen the incidence of post thoracotomy pain.

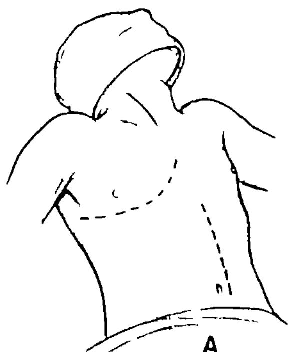
X. The completed closure of the skin incision with interrupted silk (000) sutures and the relation of the water seal drainage catheter to the anterior rather than the middle or posterior portions of the incision is depicted

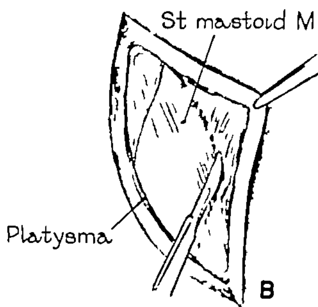
DISCUSSION—DR. GARLOCK (cont.)

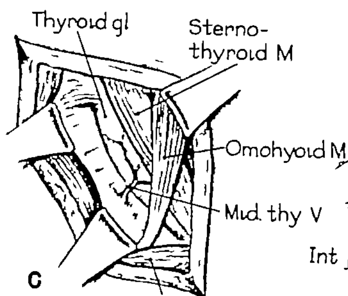
of the beginning of the greater curvature of the stomach than is depicted in Plate 55 M The step of mobilization of the duodenum is always carried out in left sided esophagectomy for the reasons previously stated.

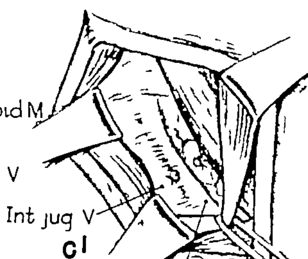
I believe there is an easier method of making the anastomosis in the supraaortic area than that depicted in Plate 55 R, R R R‴ Before placing the first posterior row of sutures, a button of stomach wall is excised from the upper anterior wall of the stomach All vessels are carefully ligated with very fine silk. After aspiration of stomach contents (blood and mucus) the opening is approximated to the esophagus at a site proximal to the area of *subsequent transection. The first posterior layer of* sutures is now placed in a dry field, the esophagus is transected and the anastomosis is completed. Trying to ligate vessels in the stomach wall at the site of anastomosis while the stomach is located high in the chest greatly complicates the details of an already difficult procedure.

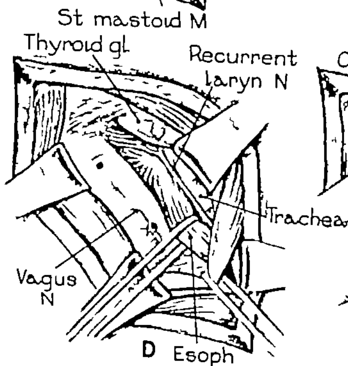
Finally I have abandoned the operation of infraaortic anastomosis for squamous cell tumors of the distal esophagus because it is important to excise as much esophagus as possible proximal to the growth in order to get well beyond the submucosal spread so frequently seen in this location

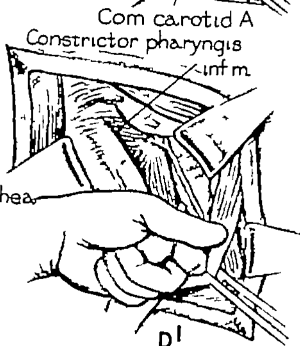

A


St mastoid M
Platysma
B


Thyroid gl
Sterno-
thyroid M
Omohyoid M
Mid. thy V
C
St mastoid M


Int jug V
C I
Com carotid A


Thyroid gl
Recurrent
laryn N
Trachea
Vagus
N
D
Esoph


Constrictor pharyngis
inf m.
D I

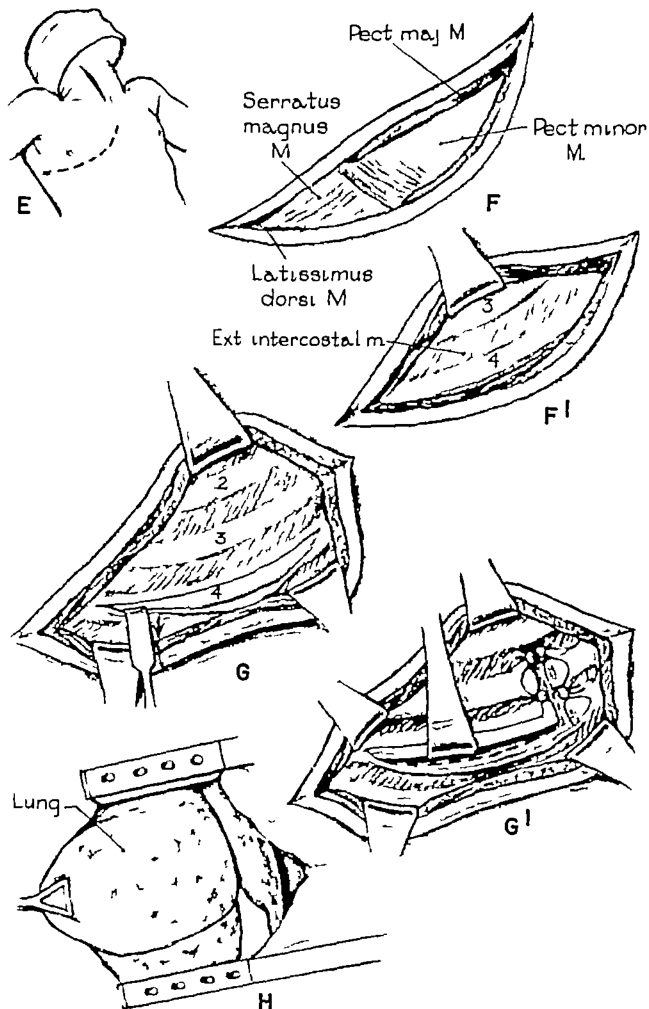
ESOPHAGECTOMY COMBINED RIGHT CERVICAL, RIGHT THORACIC, AND LEFT ABDOMINAL APPROACH WITH CERVICAL ESOPHAGOGASTROSTOMY

A. The patient is placed in the supine position and the head is rotated to the left. The cervical incision the first to be made is demonstrated by the solid line The right anterior thoracotomy and the left upper paramedian abdominal incisions, which are made in the order mentioned, are indicated in dotted outline

B. The cervical incision is deepened through the subcutaneous fatty tissue and the platysma muscle layers to expose the sternomastoid muscle the anterior border of which is being mobilized by scalpel dissection.

C. The mobilized anterior border of the sternomastoid muscle is retracted posteriorly and the underlying anatomic structures are exposed.

C' D D' The middle thyroid vein is firstly doubly ligated (000 silk) in continuity and then severed between the ligatures (C') This permits retraction of the right lobe of the thyroid gland anteriorly toward the midline and exposure of portions of the recurrent laryngeal nerve the trachea, and the esophagus (D). The cervical portion of the esophagus, mobilized by finger dissection is encircled by a traction tape of rubber tissue The left index finger of the surgeon is inserted along the outside of the esophagus into the superior mediastinum and the tumor located in this segment of the esophagus is palpated (D') The use of this maneuver at this time may frequently indicate whether or not the lesion is locally resectable and thereby avoid the necessity of making either a thoracotomy or abdominal incision.



E
Pect maj M
Serratus
magnus
M
Pect minor
M
F
Latissimus
dorsi M
3
Ext intercostal m
4
F 1
2
3
4
G
G 1
Lung
H

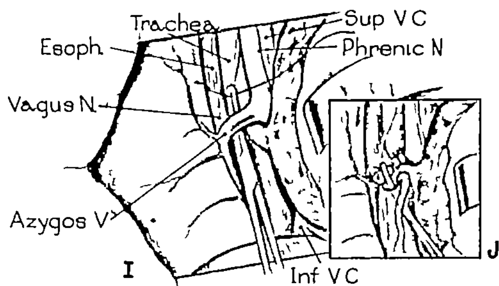
E. The cervical mediastinotomy and the digital exploration of the superior mediastinum is completed. The second incision to be made, a right anterolateral thoracic incision, is indicated in dotted outline.

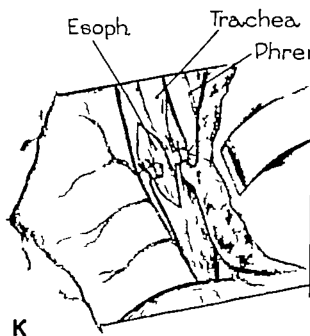
F, F[1]. The incision is deepened through the underlying pectoralis major and the latissimus dorsi muscles, the superficial muscle layers (F), and then through the pectoralis minor and serratus anterior (magnus) muscles, the deep muscle layers, to expose the rib cage and one of the related intercostal muscle layers (F[1]).

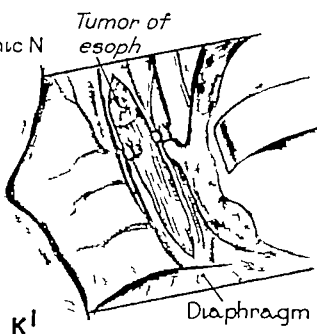
G. The wound margins are retracted and portions of the second, third, and fourth ribs are exposed. An incision is made in the periosteum throughout the length of the exposed portion of the fourth rib and with a periosteal elevator the periosteum is removed from the lower half of the rib.

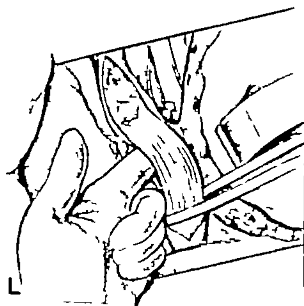
G[1]. The dissection of the periosteum from the fourth rib posteriorly is completed, and, by blunt digital dissection, a plane of cleavage is obtained between the endothoracic fascia and the posterior aspects of the second and third ribs respectively after the manner of Sir R. C. Brock. The adjacent intercostal muscle bundles are doubly clamped, severed, and ligated with suture ligatures of 000 silk. The incision in the endothoracic fascia and the parietal pleura behind the fourth rib is shown in dotted outline.

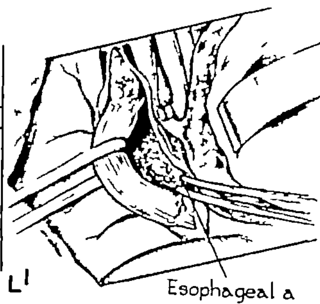
H. The right pleural cavity is entered and the wound margins are retracted over protective moist towels with a self retaining retractor (Finochietto) to expose portions of the lobes of the lung.


Trachea
Sup VC
Esoph
Phrenic N
Vagus N
Azygos V
I
J
Inf VC


Esoph
Trachea
Phrenic N
K


Tumor of esoph
Diaphragm
K'


L

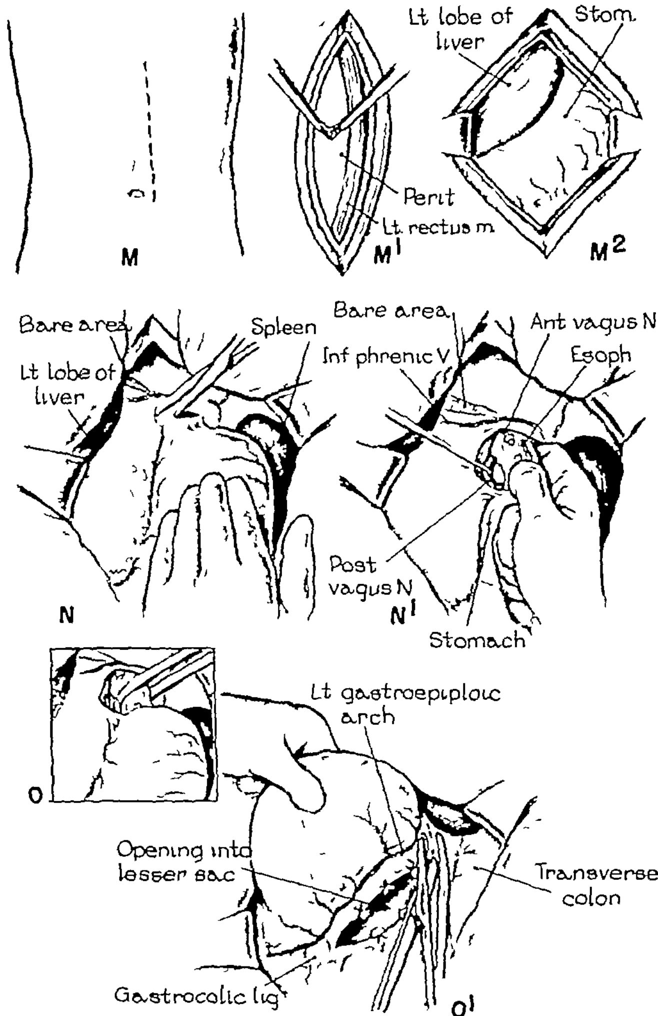

L'
Esophageal a

I J The right lung is retracted anteriorly and toward the midline to expose the related structures posteriorly The azygos vein is mobilized on a curved clamp preparatory to withdrawing the first of two silk (00) ligatures for ligation of the vein in continuity (I) Subsequently the azygos vein is doubly clamped between the two ligatures and severed Each clamp is then replaced by a suture ligature of 00 silk (J)

K, K[1] The severance and ligation of the azygos vein is completed (K) and the mediastinal pleura is incised to expose the thoracic segment of the esophagus and the tumor located in its proximal portion above the aortic arch (K)

L The caudad end of the thoracic esophagus is encircled by a cotton tape for traction as mobilization of the esophagus is continued by blunt digital dissection.

L[1] The partially mobilized thoracic esophagus is retracted laterally and posteriorly and the second of two of the esophageal arterial branches from the thoracic aorta is doubly clamped prior to its severance. One of the ligated stumps of the esophageal artery previously ligated and severed is also visible

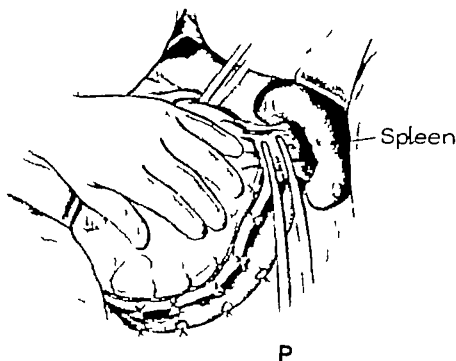

M
Lt lobe of liver
Stom.
Perit
Lt. rectus m.
M1
M2
Bare area
Spleen
Lt lobe of liver
N
Bare area
Ant vagus N
Inf phrenic V
Esoph
Post vagus N
N1
Stomach
O
Lt gastroepiploic arch
Opening into lesser sac
Transverse colon
Gastrocolic lig
O1

M M[1] M[2] The third incision an upper left paramedian muscle retracting (lateral) abdominal incision is depicted in dotted out line (M). This incision is deepened through the anterior rectus sheath, and the under lying left rectus muscle is mobilized from its midline attachment (M) An incision is made in the posterior rectus sheath and anterior parietal peritoneum, and the incised margins are grasped in clamps (M) pre paratory to extension of the incision both cephalad and caudad to expose the under lying intraperitoneal viscera (M).

N The left lobe of the liver mobilized by severance of the avascular left triangular ligament is turned downward on itself and retracted toward the midline. By manual traction the stomach is displaced downward and by scissor dissection an opening is made through the musculofascial fibers of the diaphragm overlying the lower end of the esophagus immediately cephalad to the esophagocardial junction

N[1] By digital dissection within the posterior mediastinum the lower end of the esophagus is mobilized on the index finger The anterior (left) vagus nerve is severed and a silver brain (Cushing) clip is applied to its proximal cut end. The posterior (right) vagus nerve is mobilized on a nerve hook prior to its severance The transection of the vagus nerves is a technical aid in the freeing of the esophagus from its surrounding attachments.

O O[1] The completely freed lower end of the esophagus is encircled by a tape of rubber tissue for both future identification and traction (O) Mobilization of the greater curvature of the stomach below the gastroepiploic arch is begun by serially clamping and severing the gastrocolic ligament (O). The maintenance of continuity of the gastroepiploic arch is important in assuring an adequate blood supply to the stomach when its mobilization is completed



P

Rt gastro-epiploic A

Pancreas

Trans mesocolon

Gastroduod A

Sup pancreaticoduodenal A

Q

Q[1]

Gastro-hepatic lig

Rt.gastric a.

Duod

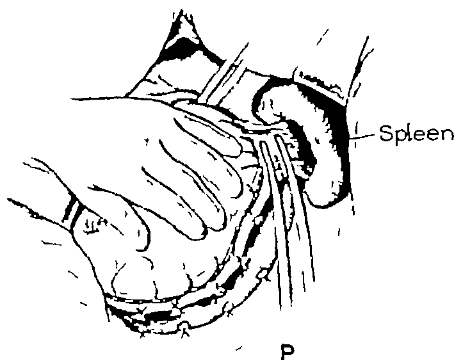
Q[2]

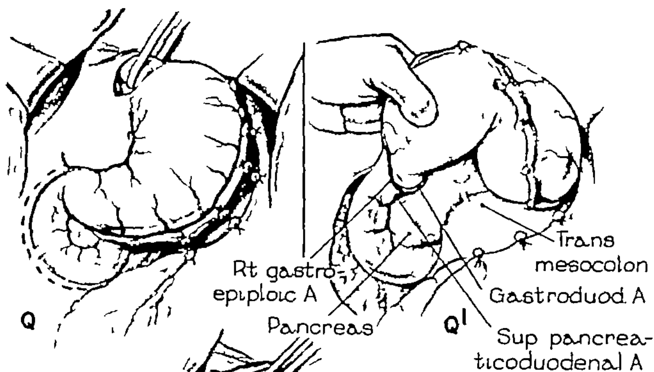
M M[1] M The third incision, an upper left paramedian muscle retracting (lateral) abdominal incision is depicted in dotted out line (M). This incision is deepened through the anterior rectus sheath and the under lying left rectus muscle is mobilized from its midline attachment (M) An incision is made in the posterior rectus sheath and anterior parietal peritoneum, and the incised margins are grasped in clamps (M) preparatory to extension of the incision both cephalad and caudad to expose the under lying intraperitoneal viscera (M²)

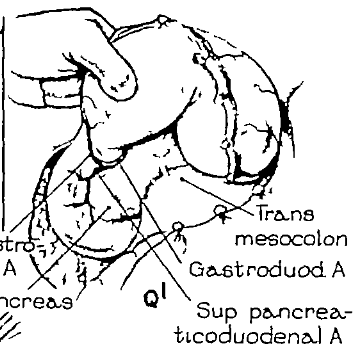
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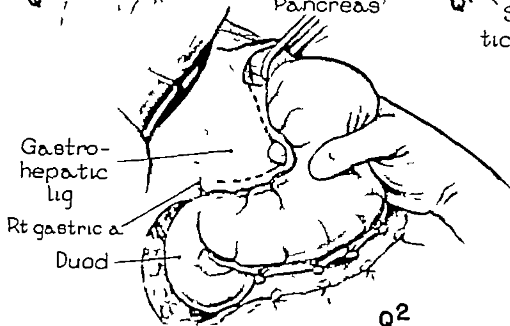
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Spleen
P


Q


Trans
mesocolon
Rt gastro-
epiploic A
Gastroduod A
Pancreas
Q1
Sup pancrea-
ticoduodenal A


Gastro-
hepatic
lig
Rt gastric a
Duod
Q2

P Mobilization of the greater curvature and fundus of the stomach is continued by serially clamping and severing the gastrosplenic ligament and its contained vasa brevia

Q Upon completion of the mobilization of the fundus of the greater curvature of the stomach, an incision indicated by the dotted line is made in the posterior parietal peritoneum lateral and inferior to the descending (second part) and horizontal (third part) portions of the duodenum before freeing it by blunt digital dissection posteriorly

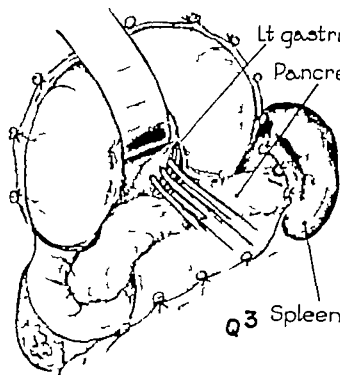
Q[1] The duodenal loop and the head of the pancreas are mobilized by blunt digital dissection in the relatively avascular areolar tissue plane posteriorly and the related anatomic structures are depicted The dissection of the horizontal portion of the duodenum is continued medially until the superior mesenteric vascular stalk and the uncinate process of the pancreas are identified In this dissection caution must be observed to avoid making a rent in the base of the mesentery of the colon through which the small bowel may herniate

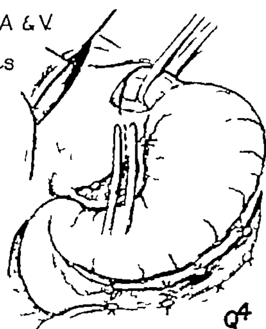
Q[2] The finger of the right hand of the surgeon is inserted behind the mobilized greater curvature of the stomach, and after transgressing the lesser sac, an opening is made in the velumous gastrohepatic ligament from behind by blunt digital dissection. The transection of this ligament to mobilize the whole of the lesser curvature of the stomach is indicated by the dotted line The continuity of the right gastric artery on the lesser curvature similar to the continuity of the right gastroepiploic artery on the greater curvature is preserved.

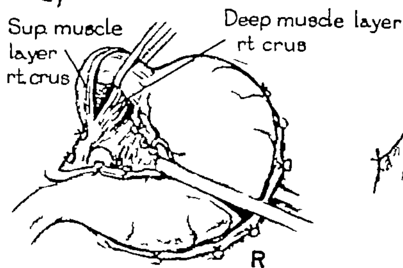
Discussion—Dr John H Garlock It has been and still is my practice to use the right sided approach for cancers of the esophagus located behind the aortic arch or more proximally up to the general level of the suprasternal notch The technic of Ivor Lewis, requiring three separate incisions, as depicted in A, Plate 57 has been replaced by a right thoracoabdominal incision, traversing the sixth or seventh interspace with division of the cartilaginous costal arch and extension downward along the upper midabdomen Of course, the final esophagogastric anastomosis in the neck requires a cervical incision either on the right or left side, depending on how easily the cervical esophagus swings to one or the other side. To accomplish this operative approach, the thoracic portion of the operation can be more expeditiously carried out if the patient is tilted forward about 45 degrees. When mobilization of the stomach becomes indicated, the table may be tilted backwards so that the patient assumes the straight supine position This makes it much easier to separate the stomach from its vascular attachments and permits the surgeon to handle the stomach with a minimum of trauma, an important feature in the prevention of thrombosis in the stomach wall. The cervical incision is, therefore, the last one made, after it has been determined that one is dealing with a resectable tumor It is usually not possible to determine operability of an esophageal cancer located in the superior mediastinum by finger exploration through the cervical incision.

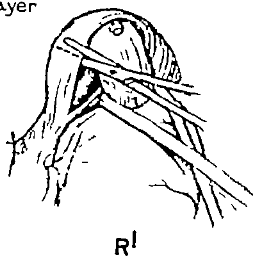
With the use of the thoracoabdominal incision, it is unnecessary to remove ribs, thereby eliminating all possibility of subsequent intercostal neuralgia, a disabling aftermath which frequently follows the maneuvers depicted (Plate 58, E through H)

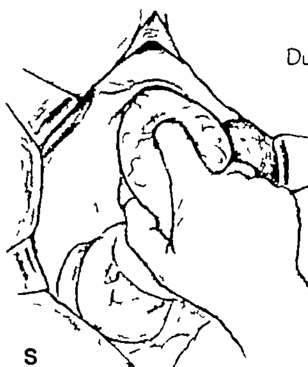
Dissection of the esophagus from the mediastinum should include all removable areolar tissue and careful ligation of the segmental esophageal arteries arising from the descending aorta. Fatal postoperative

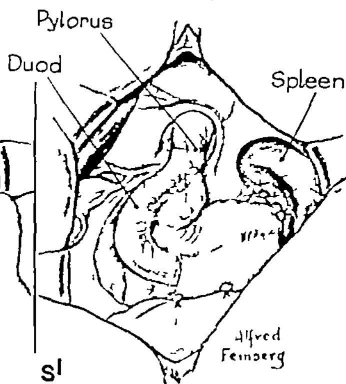

Lt gastric A & V
Pancreas
Spleen
Q3


Q4


Sup. muscle layer rt. crus
Deep muscle layer rt crus
R


R1


S


Pylorus
Duod
Spleen
Alfred Feinberg
S1

P Mobilization of the greater curvature and fundus of the stomach is continued by serially clamping and severing the gastrosplenic ligament and its contained vasa brevia.

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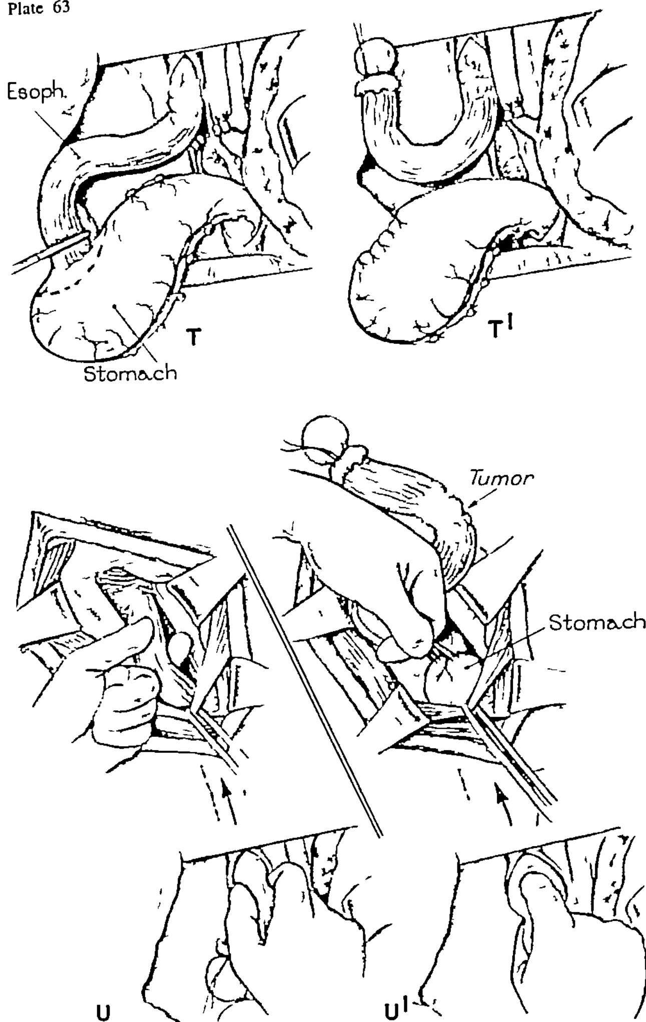
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With the use of the thoracoabdominal incision, it is unnecessary to remove ribs, thereby eliminating all possibility of subsequent intercostal neuralgia, a disabling aftermath which frequently follows the maneuvers depicted (Plate 58, E through H)

Dissection of the esophagus from the mediastinum should include all removable areolar tissue and careful ligation of the segmental esophageal arteries arising from the descending aorta. Fatal postoperative

Plate 63



Q[3] The mobilized greater curvature of the stomach is rotated anteriorly and retracted cephalad to demonstrate the left gastric vessels contained within the gastropancreatic fold of peritoneum triply clamped prior to severance between the two distal clamps.

Q[4] The stomach is replaced in its normal position and the remaining intact segment of the gastrohepatic ligament is serially clamped and severed as indicated.

R. The mobilization of the lesser and the greater curvatures of the stomach is com pleted and the lower portion of the esoph agus and proximal portion of the stomach are retracted to expose the hiatal ring which is formed by the separation of the muscle fibers of the right crus into superficial and deep muscle layers.

R[1] The cardioesophageal region, encircled by a cotton tape for traction, is d downward and laterally to demons transection of the superficial layer cle fibers of the right crus which f right margin of the hiatal ring. T neuver enlarges the hiatal ring an tates the transplantation of the m stomach from the peritoneal cavity right pleural cavity

S. By manual manipulation from be upward traction from within the incision above, the stomach is d through the enlarged esophageal hi the right pleural cavity

S[1] The transplantation of all but t segment of the pyloric portion of t ach into the right pleural cavity pleted, and the change in positio related viscera within the peritone is illustrated

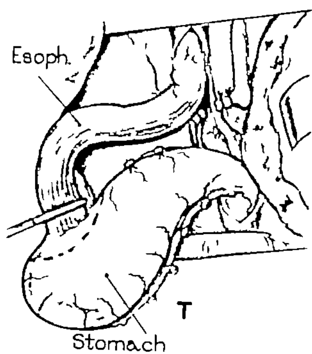
Discussion—Dr Garlock (cont)

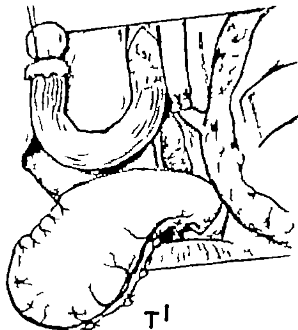
hemorrhage has been known to occur from one of these vessels ligated too close to the aorta

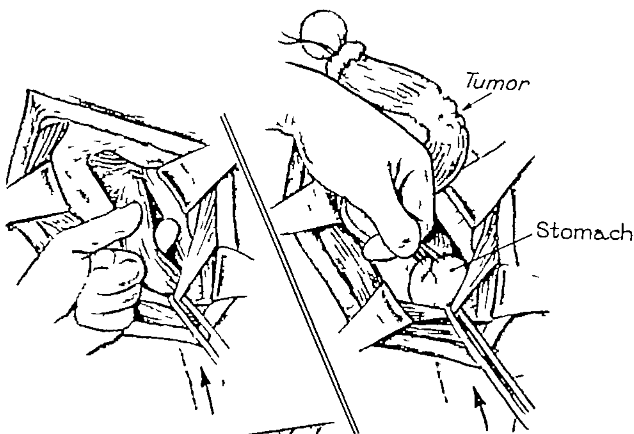
The importance of gentle handling of the stomach through all phases of its mobilization and subsequent transplantation in the chest cannot be overempha sized There is every reason to believe that local trauma may produce thrombosis and localized necrosis with perforation in the early postoperative period Another important feature in the adequate mobiliza tion, depicted in Plate 61 Q and Q[1] is concerned with the freeing of the second and third parts of the duodenum This maneuver prevents axial rotation of the duodenum when the stomach is transplanted into the chest and also provides increased length to the stomach in its new position

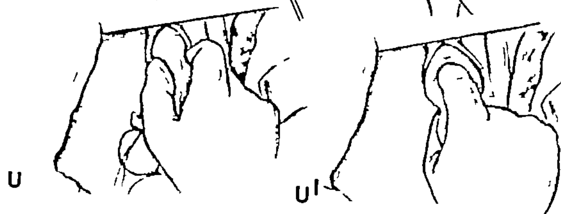
In Plate 63 T the line of transection of the stomach is indicated by a dotted line I would sug gest removal of at least two more inche beginning of the greater curvature so that of transection is more oblique than depic reason for this is that the most precari from the standpoint of adequate blood s located here. Almost all postoperative have occurred in this region This usua complication has been obviated in recent removal of the potentially dangerous area

The importance of not inserting too man at the anastomosis is clearly shown in V thi Plate 64 Oversuturing this area may lea literation of the tenuous blood supply of phageal stump which receives its nourishm from small branches of the inferior thy teries.


Esoph.
Stomach
T


T'

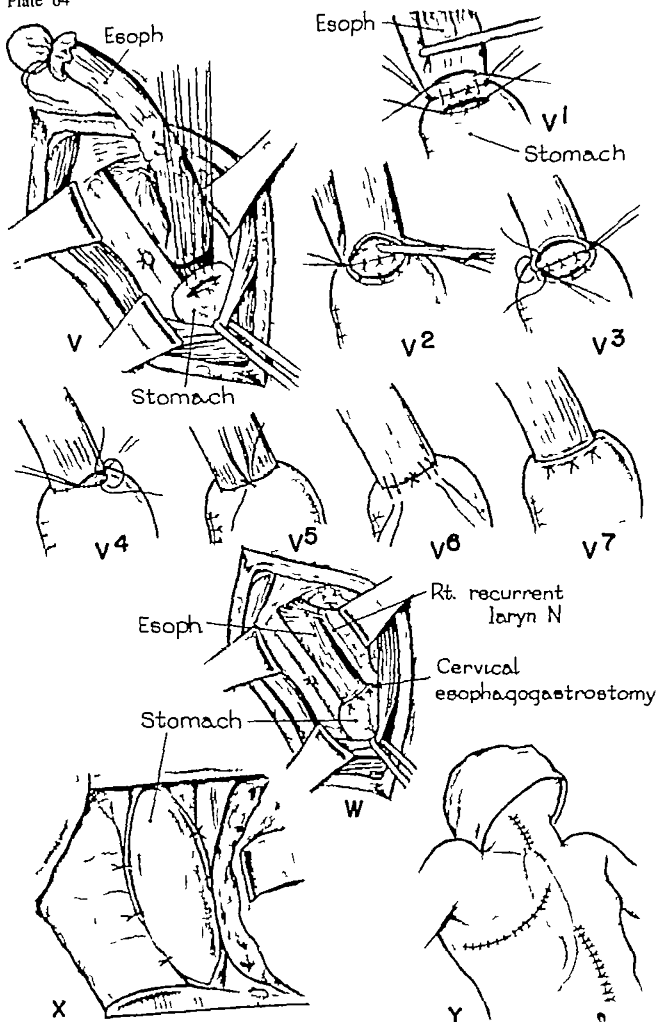

Tumor
Stomach


U
U'

T T[1] The completion of the transplantation of the stomach into the right pleural cavity is shown. The lower end of the esophagus is occluded by a clamp preparatory to the resection of a subjacent segment of the stomach which is indicated by the dotted line Accordingly resection of the whole of the caudad portion of the esophagus is assured. The transected esophagogastric stump is occluded with a piece of rubber dam and the opening in the gastric lumen is closed in two layers using interrupted sutures of 000 silk (T)

U U[1] By a combination of digital traction through the cervical incision and manual manipulation from within the thoracic incision (U), the mobilized thoracic and abdominal segments of the esophagus are displaced upward into and out through the right cervical incision (U). In like manner the fundus of the transplanted stomach, secured by traction guy sutures of silk (00), is mobilized into the cervical mediastinum (U)

Plate 64


Esoph
Stomach
V
Esoph
Stomach
V1
V2
V3
V4
V5
V6
V7
Esoph
Rt. recurrent
laryn N
Cervical
esophagogastrostomy
Stomach
W
X
Y

V For technical expediency an opening is made in the fundic portion of the stomach before the insertion of the interrupted silk sutures (000) which form the first posterior layer of the esophagogastric anastomosis. To increase the holding power of the tissues of the esophagus these sutures are inserted in the wall of the esophagus at right angles to its longitudinal layer of muscle fibers.

V^1 The first posterior layer of sutures is tied to approximate the posterior wall of the stomach and the fundus of the esophagus. Two of the series of through and through interrupted sutures which will comprise the second posterior layer are inserted at either angle of the anastomosis but are not tied.

V^2 The insertion of the second layer of sutures posteriorly is completed and the transection of the esophagus anteriorly is being completed by scissor dissection

V^3 The first anterior layer of the anastomosis consists of a series of interrupted silk (000) sutures which are inserted from the "inside out" to the "outside in" so that, when tied, the knots are on the inside of the lumen. The first angle suture anteriorly is inserted but not tied. Traction in the long axis of the anastomosis is applied to the strands of the angle suture posteriorly as the anterior angle suture is tied. This facilitates the inversion of the first layer of the anastomosis anteriorly

V^4 V^5 V^6 V^7 The interrupted sutures are inserted alternately from either end toward the center (V) where the first layer anteriorly terminates (V^4) The site of termination of these sutures is encircled by a figure of 8 mattress suture (V^5) which, when tied (V^5) lessens the likelihood of an anastomotic leakage For the second layer anteriorly a series of interrupted mattress sutures (000 silk) is used (V^6) These sutures are inserted at right angles to the layer of longitudinal muscle fibers of the esophagus (V^6) and when tied (V^7) a telescoping of the esophagus into the serosal lined wall of the stomach is effected

W This is a view through the cervical incision showing the completed esophagogastrostomy and its relation to the surrounding structures.

X. This is a view from within the right pleural cavity showing the right lung retracted anteriorly toward the midline and the transplanted stomach attached to the cut margins of the mediastinal pleura with a series of interrupted silk (000) sutures.

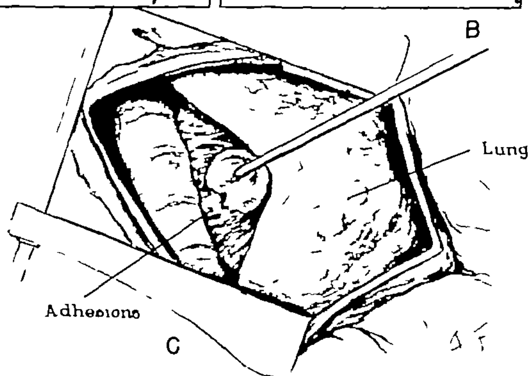
Y The operation is completed and the cervical, thoracic, and abdominal incisions are closed The relation of the transplanted stomach to these incisions is depicted in transparent outline.



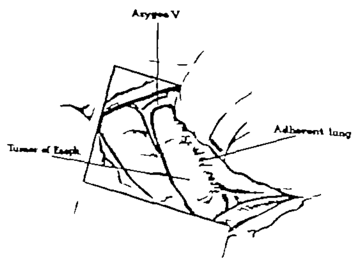
A


Bed of 6th rib

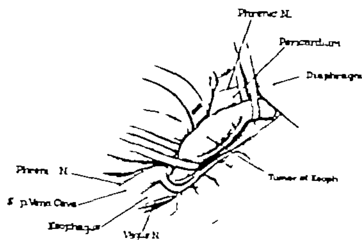
B


Lung
Adhesions

C


Azygos V
Adherent lung
Tumor of Esoph

D


Phrenic N.
Pericardium
Diaphragm
Phrenic N
S. p. Vena Cava
Tumor of Esoph
Esophagus
Vagus N

E

ESOPHAGECTOMY—RIGHT TRANSPLEURAL APPROACH

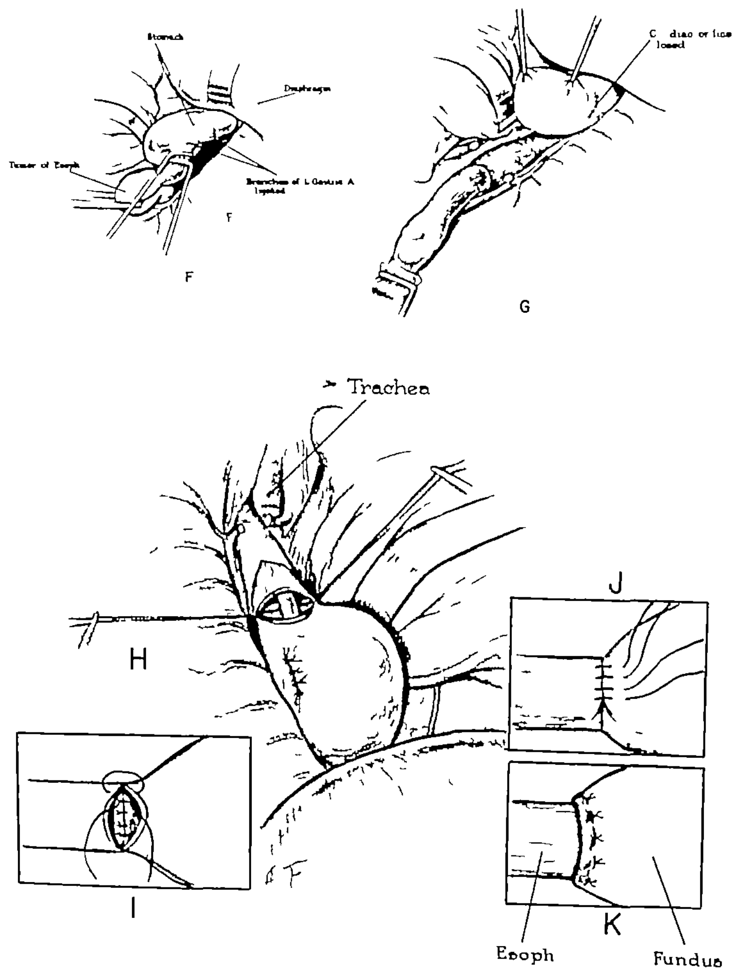
A. The patient is placed in the direct left lateral prone position with the left side elevated on a pillow support. The oblique posterolateral incision is shown by the solid line and its subsequent anterior extension by the broken line.

B. The sixth rib is partially resected, as is a segment of the fifth rib posteriorly This additional segmental resection posteriorly is usually unnecessary The severed and ligated ends of the fifth intercostal muscle bundle are visible

C. The pleural cavity is entered through an incision in the bed of the sixth rib and the rib margins are retracted. Filmy adhesions between the lung and the underlying esophagus are separated by blunt dissection with a gauze pledget

D The tumor of the esophagus is now exposed, and its relation to the remaining adherent segment of the right lung is visible

E. The dissection of the adherent lung is completed, and the mobilized tumor bearing segment of the middle and lower thirds of the esophagus is encircled by cotton tapes and elevated from its "bed" in the posterior mediastinum The relation of the tumor to the surrounding structures is depicted.


Stomach
Diaphragm
Tumor of Esoph
Branches of L Gastric A ligated
F
F
G
Trachea
H
J
I
K
Esoph
Fundus

F The stomach is mobilized upward through the esophageal hiatus into the right pleural cavity During the transplantation from the peritoneal to the pleural cavity branches of the left gastric artery were clamped, severed, and ligated to free the lesser curvature of the stomach The esophagus at the esophagocardial junction is doubly clamped with right-angled clamps and transected between the clamps as indicated by the broken line.

G. The cardiac orifice of the stomach is closed in two layers using interrupted sutures of 000 silk The fundus of the stomach is elevated with forceps and the site of the anastomotic incision is indicated (broken line) The proximal transected end of the esophagus is retracted cephalad and the opening to be made into its lumen for anastomosis with the fundus of the stomach is represented by the broken line

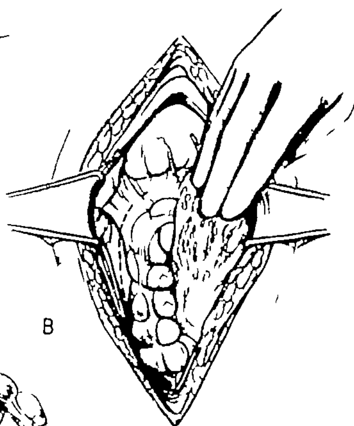
H. *The two-layer anastomosis posteriorly is* completed, interrupted sutures of 000 silk being used. The first layer is an approximation of the serosa of the stomach to the muscle wall of the esophagus. The second layer is comprised of a series of through-and-through sutures that include all the layers of the cut margins of the esophagus and stomach. The Levin tube is inserted beyond the anastomosis into the lumen of the stomach.

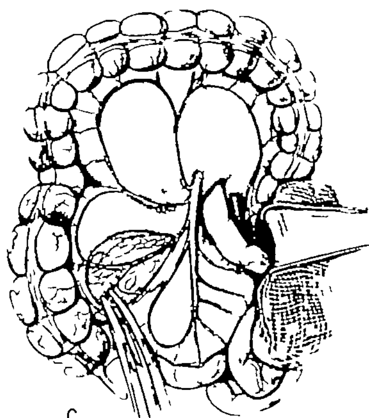
I. *The first suture layer anteriorly* is begun. Each suture is inserted from the inside-out on the esophagus and from the outside-in on the stomach, so that when tied the knot is on the inside of the lumen. Medial traction on the suture previously inserted facilitates the inversion of the cut margins. The sutures are inserted alternately from either end and terminate in the center of the anastomosis, where they are encircled by a figure-of-8 mattress suture to complete the first anterior layer of sutures.

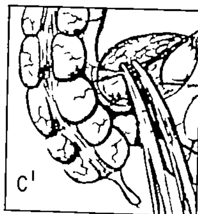
J The second anterior layer of the anastomosis is comprised of a series of interrupted mattress (Lembert-Cushing) sutures that are inserted at right angles to the longitudinal muscle fibers of the esophagus to reinforce the holding power of the tissue.

K. The mattress sutures are all first inserted and tied individually and then cut to complete the esophagogastrostomy When tied, the sutures forming the second anterior layer effect a cap-like covering of serosa on the esophagus.


A


B


C

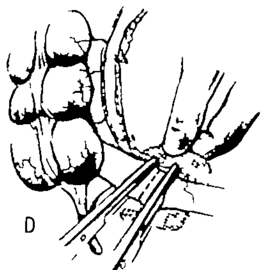

C'

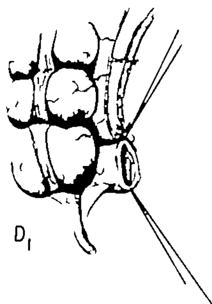
ESOPHAGECTOMY AND COLON TRANSPLANT

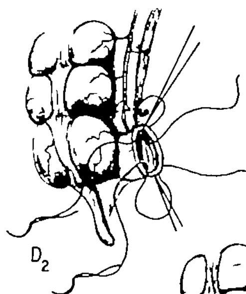
A. The patient is placed in the supine position, and the right side is elevated to a 20 25° angle with the horizontal. The right paramedian abdominal incision and the right anterolateral thoracic incision are indicated by solid and broken lines, respectively

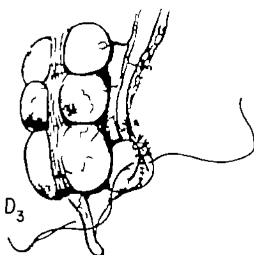
B. The peritoneal cavity is entered, and the right side of the colon is mobilized by severance of the fascia fusion layer Toldt ("white line") and the right phrenocolic ligament as indicated by the broken line The transverse colon is subsequently mobilized by dissection of the relatively avascular attachments of the greater omentum.

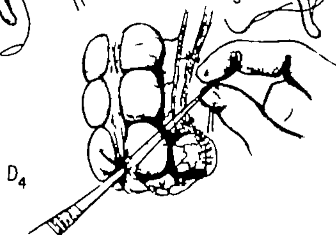
C, C' The superior mesenteric artery and its branches in relation to the small and large bowel are depicted (C) The mobilization of the ileocolic segment for esophageal bypass is begun by the transection of the branches of the ileocolic artery proximal to the marginal colic artery (C, C')


D


D_1


D_2


D_3


D_4

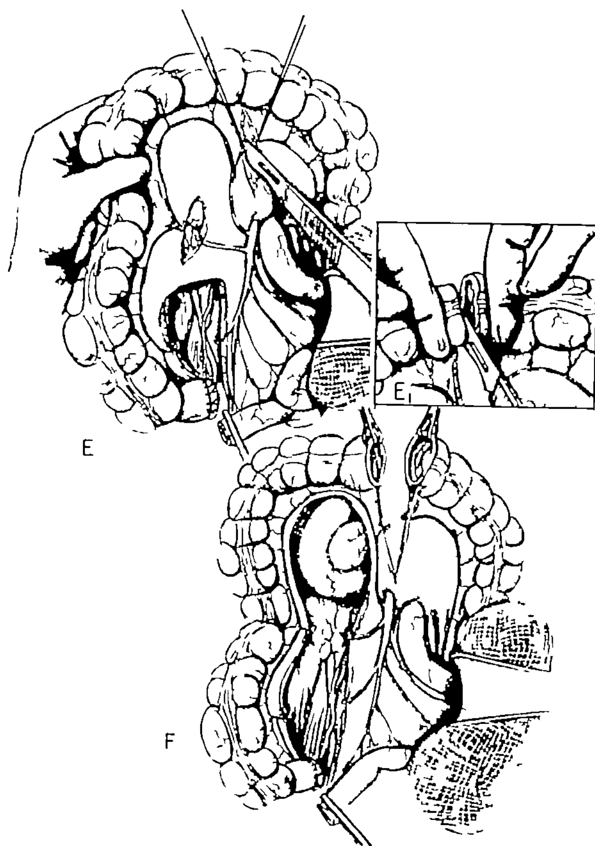
D. The mobilized segment of cecoascending colon and its intact marginal artery are visible. The terminal ileum is severed (broken line) between clamps, the jaws of which are held firmly together but not locked.

D_1, D_2, D_3, D_4. The distal end of the terminal ileum is inverted in two layers, using interrupted sutures of 000 silk as indicated. The first layer of sutures is inserted from the inside-out to the outside-in (D_2) so that, when tied, the knots are on the inside of the lumen. For the second layer of closure interrupted seroserosal or Lembert sutures are employed (D_3). The appendix is then removed and its stump inverted with a pursestring suture of 000 silk (D_4).

DISCUSSION—DR. EARLE B. MAHONEY. The use of colon transplant in esophageal surgery, which has become a commonly accepted procedure during recent years, may be used in a rather wide variety of conditions. The right or the left colon may be used to reconstitute the gastrointestinal tract following total esophagectomy for carcinoma or for replacement when benign lesions, such as intractable strictures, may require esophagectomy. The colon may be used as a bypass for intractable strictures or as a palliative bypass around an inoperable carcinoma. The choice of whether the right or left colon is used depends on a surgeon's experience, but I prefer the right colon and frequently use the distal right colon with terminal ileum. The technic of the operation is very demanding, and extreme care must be used in handling tissue. Failure to observe the minute details of careful surgical technic will lead to necrosis of the transplant and failure of the operative procedure.

The technic of esophagocoloplasty for bypass of a lesion in the lower esophagus is very well illustrated and accurately described. This technic may be used when a benign or malignant lesion is encountered, usually one causing obstruction and in the presence of a normal proximal esophagus. There are, however, several alternate minor details of technic that may at times be very helpful. In the procedure illustrated the terminal ileum is not used in the transplant but is turned in and closed, as indicated in Illustrations D-D_4. The vascular arcades of the terminal ileum and of the cecum vary in individuals, and I have found that frequently a much longer segment of the terminal ileum may be saved with very adequate blood supply and this can be used for the proximal anastomosis to the esophagus. In this technic it may be necessary to use only a portion of the ascending colon in addition to the terminal ileum. This involves, of course, conserving a longer segment of the ileo-colic vessels and utilizing the anastomotic arcades to the terminal ileum.

E shows division of the ileocolic artery and of


E
E1
F

E. The ileocecal segment is mobilized, and its relation to the retroperitoneal structures—viz., the ureter the spermatic vessels and the psoas muscle—is visible The right colic artery in juxtaposition to the marginal colic artery is transected and ligated, and the left branch of the middle colic artery is being transected between ligatures by a scalpel

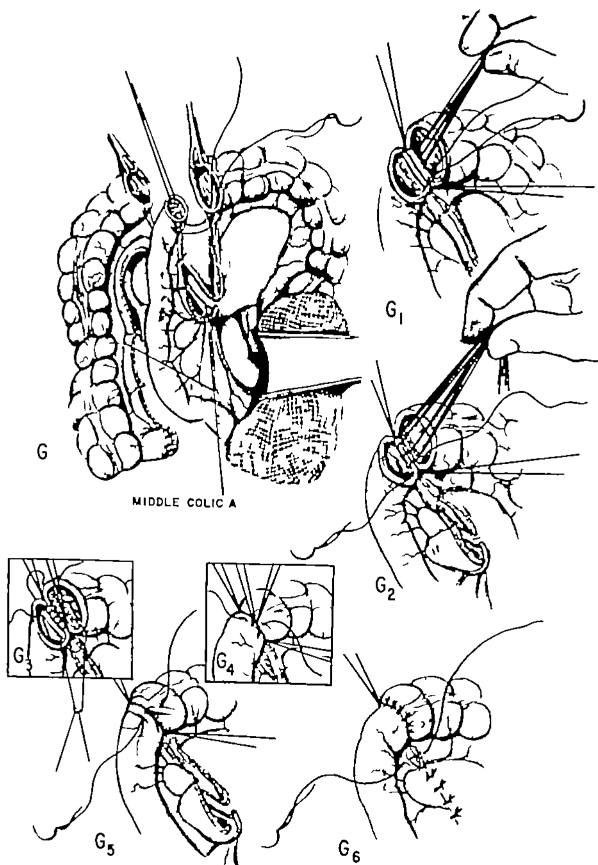
E_1 The transverse colon is compressed between fingers rather than clamps as it is transected at the site of election in the mid-transverse colon

F The mobilization of the ileocolic segment is completed, and its relation to the surrounding structures is visible. The viability of the mobilized bowel segment is maintained through the marginal artery by the middle colic artery and its intact right branch

Discussion—Dr. Mahoney (cont.)

the right colic artery I prefer to temporarily occlude these vessels at the point where division is anticipated and observe the circulation in the colon segment for fifteen or twenty minutes before making the decision as to the points of ligation. During this time if the circulation to the transplant is to be adequate one can see pulsations in the marginal arteries. This time need not be wasted, because the appendix may be removed and the ileum divided at the appropriate level while the vessels are temporarily occluded In addition, it has been my custom to divide the right colic artery immediately adjacent to its origin from the superior mesenteric, since this gives a larger number of vessels feeding the marginal artery By appropriate incisions in the mesentery adequate length may be obtained even though numerous branches of the artery have been left. Also, E indicates that the left branch of the middle colic artery is being ligated and divided In my experience the middle colic usually bifurcates sufficiently low that it is not necessary to divide its left branch The colon is divided and the mesentery split down to the division of the middle colic artery and the left branch may be preserved If this artery is divided, one depends on the left colic artery entirely for the viability of the splenic flexure of the colon.

G shows the manner in which the terminal


G
MIDDLE COLIC A
G1
G2
G3
G4
G5
G6

G The open end-to-end ileocolostomy is begun by the insertion of the mesenteric coapting suture (Lee) which, when tied, closes the mesenteric angles of each intestinal segment. The mesenteric vascular stalk (middle colic artery) and marginal artery of the excluded ileocolic segment are depicted

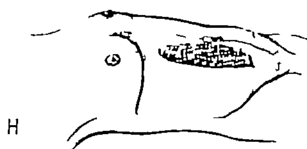
G_1, G_2. The insertion of the last of a series of horizontal mattress sutures (000 silk) comprising the first posterior layer of the anastomosis is completed (G_1) When tied, these sutures evert the cut margins of the intestines and facilitate the insertion of the interrupted through-and-through (all layers) sutures that comprise the second suture layer posteriorly (G_2)

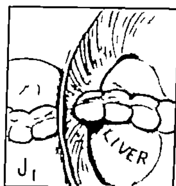
G_3, G_4 The sutures (000 silk) at each angle of the anastomosis are inserted from the inside-out on the ileal side and from the outside-in on the colon side, so that when tied the knots are on the inside of the lumen (G_3) These sutures are inserted alternately from either angle to terminate in the center where they are encircled by a "figure of 8" suture to complete the first anterior layer of the anastomosis (G_4)

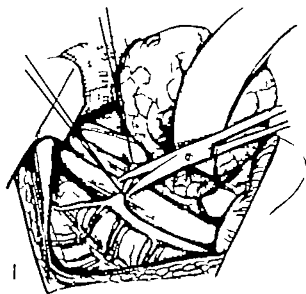
G_5, G_6. The insertion of a series of interrupted seroserosal (Lembert) sutures (G_5 G_6) completes the second layer anteriorly subsequent to which the opening in the mesentery is occluded with interrupted sutures of 000 silk (G_6)

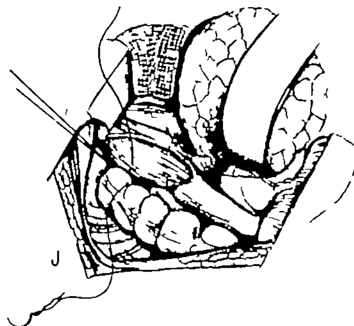
Discussion—Dr. Mahoney (cont.)

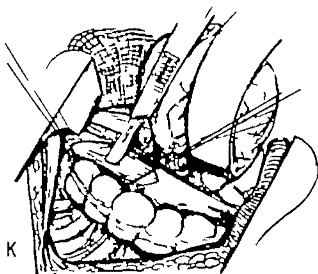
ileum is brought up anterior to the vascular pedicle of the transplant, but it should be emphasized that the vascular pedicle of the transplant is also passed behind the stomach If this is not done, compression of the pyloric end of the stomach by the middle colic artery and pyloric obstruction may result. The transplant in the illustrated procedure is brought up through an incision in the diaphragm anterior to the liver It may also be brought up through a substernal tunnel or if the esophagus has been removed, it may be brought up through the esophageal bed. Two types of anastomoses are shown between the transplant and the esophagus one a side-to-side and the other an end-to-end anastomosis. If circumstances permit, I would certainly favor the end-to-end anastomosis with division of the esophagus and if esophagectomy is not to be performed, closure of the distal esophagus. The distal end of the transplant may be anastomosed to the stomach on either the posterior or anterior surface, depending upon the position which seems to give the least tendency toward kinking. At this stage a pyloroplasty probably should be added to give adequate drainage to the stomach.

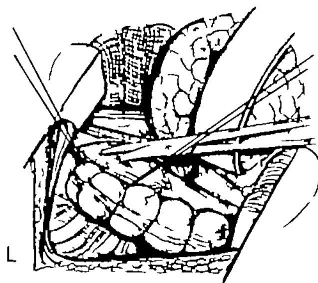

H


LIVER
J1


I


J


K

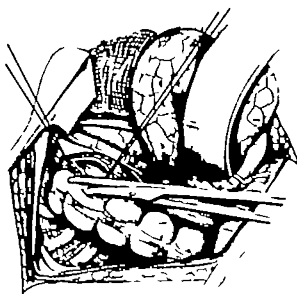

L

H. On completion of the ileotransverse colon colostomy a moist pad is placed in the abdominal wound, and the right anterolateral thoracic incision is shown.

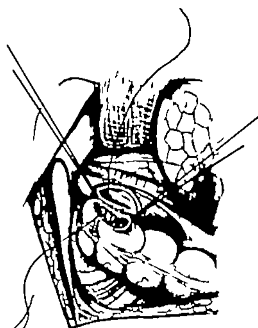
I. The right pleural cavity is entered, and the azygos vein, doubly ligated in continuity is being transected with scissors

J, J_1 The ileocecal end of the ileocolic segment is transplanted from the peritoneal cavity through an opening in the diaphragm (J_1) into the apex of the right pleural cavity where it is approximated to the side of the supra-aortic segment of the esophagus using interrupted sutures of 000 silk (J)

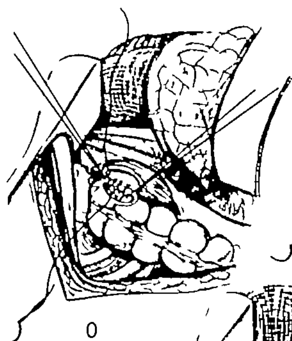
K, L. The first posterior layer of the esophagocolostomy is completed, and an incision is made into the lumen of the esophagus (K) and extended by scissor dissection (L)



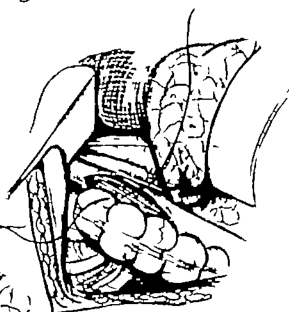
M



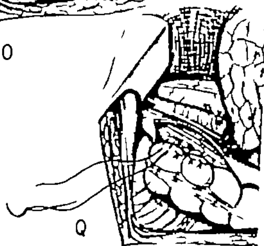
N



O



P



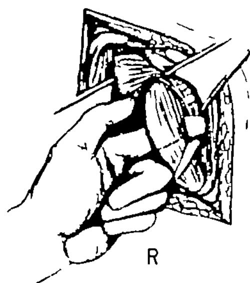
Q

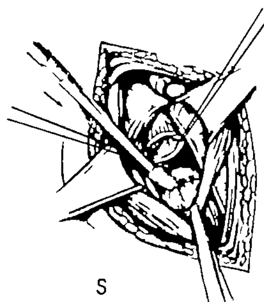
M, N The stab wound incision in the cecoascending colon is enlarged by scissor dissection (M) preparatory to the start of the second posterior suture layer (N)

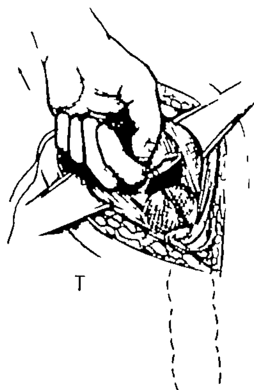
O P The first of the angle sutures is inserted cephalad and passes from the inside-out on the esophageal side and from the outside-in on the colon side so that, when tied, the knot is on the inside of the lumen (O)

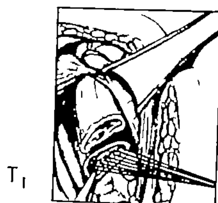
The sutures (000 silk) are inserted alternately from either angle and terminate in the center anteriorly where a "figure of 8" suture is inserted to complete the first anterior layer of the anastomosis (P)

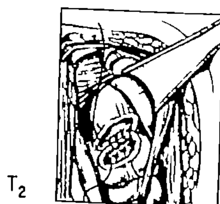
Q The last of a series of Halsted mattress sutures are inserted to complete the second layer anteriorly of the side-to-side esophagocolostomy


R


S


T


T_1


T_2

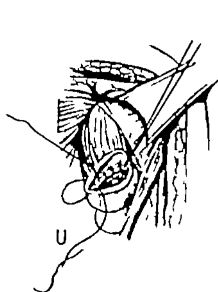
R. In some patients the location of the lesion *may necessitate the transplantation of the* colon into the cervical region. Accordingly the cervical esophagus is exposed through an oblique cervical incision that parallels the anterior border of the sternomastoid muscle The esophagus is shown elevated on the left index finger just cephalad to the superior belly of the omohyoid muscle The site of transection of the esophagus is indicated by the broken line The vagus nerve, visible between the trachea and esophagus, bifurcates just before passing beneath the lowermost fibers of the inferior constrictor muscle of the pharynx to enter the larynx.

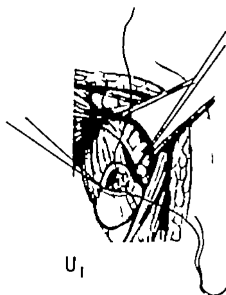
S The proximal segment of the esophagus is secured by guy sutures of 000 silk, and its distal turned-in segment is gently displaced downward into the superior mediastinum by a clamp the tip of which is covered by a gauze sponge The tendinous union between the inferior and superior bellies of the omohyoid muscle is encircled by a cotton tape for traction as indicated.

T The long strands of the ligature (No 1 silk) about the gauze covered end of the colon are used for upward traction to facilitate the transplantation of the colon from the right pleural cavity into the cervical incision.

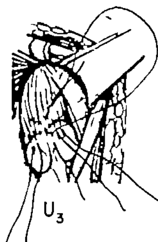
T_1 The interrupted mattress sutures of 000 silk that form the first posterior layer of the esophagocolostomy are all first inserted, and as traction is being maintained on the suture strands, the colon is approximated to the esophagus by gentle manipulation with anatomic tissue forceps.

T_2. The suture strands of the first posterior layer are tied and cut, and the last of the interrupted sutures that form the second posterior layer are inserted through the everted cut margins of the esophagus and colon

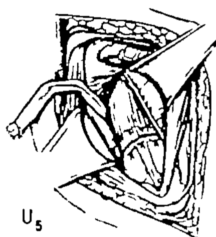

U

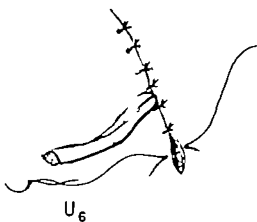

U1


U2


U3


U4

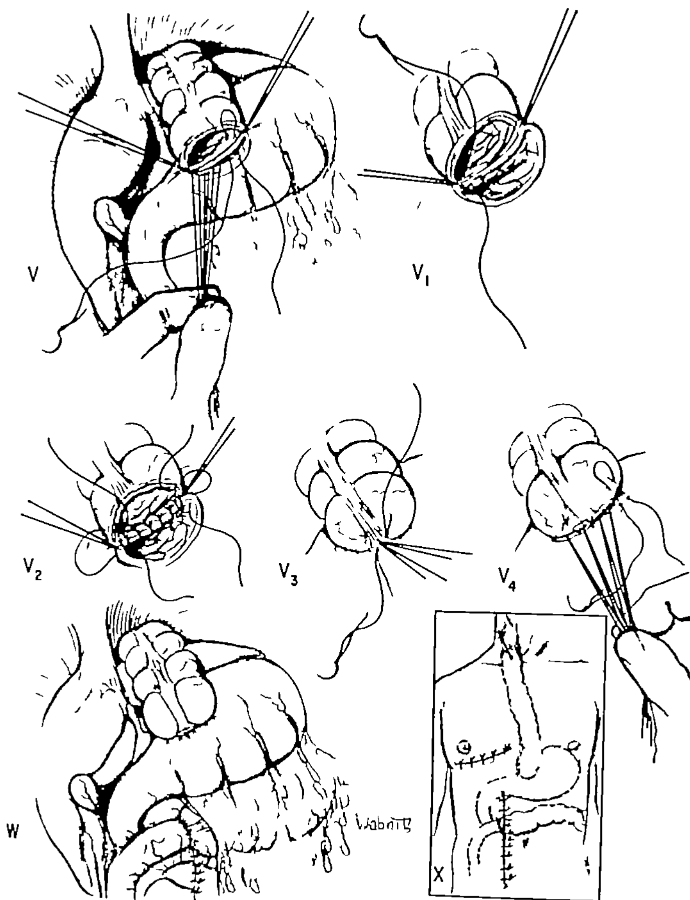

U5


U6

U U_1 U_2. Interrupted sutures (000 silk) are inserted at each angle (U) and proceed from the inside-out on the esophageal side and the outside-in on the colon side so that, when tied, the knots of the sutures are on the inside of the lumen. Sutures are inserted alternately from either angle (U_1) and as each suture is being tied, medial traction on the previously inserted suture facilitates the inversion of the tissue margins. The sutures terminate in the center anteriorly where they are encircled by a "figure of 8" suture (U_2) that, when tied, completes the first anterior layer of the anastomosis.

U_3, U_4 The second anterior layer is comprised of a series of interrupted mattress sutures (Lembert-Cushing) in which the sutures are inserted at right angles to the longitudinal muscle fibers of the esophagus to enhance the holding power of the tissue (U_3) When tied, these sutures effect a serosal cap-like covering of the suture line (U_4)

U_5, U_6. On completion of the esophagocolostomy a Penrose "cigarette" drain is inserted in juxtaposition to the anastomosis (U_5) and has its exit through the mid-portion of the cervical incision, which is closed with interrupted sutures of 000 silk (U_6)

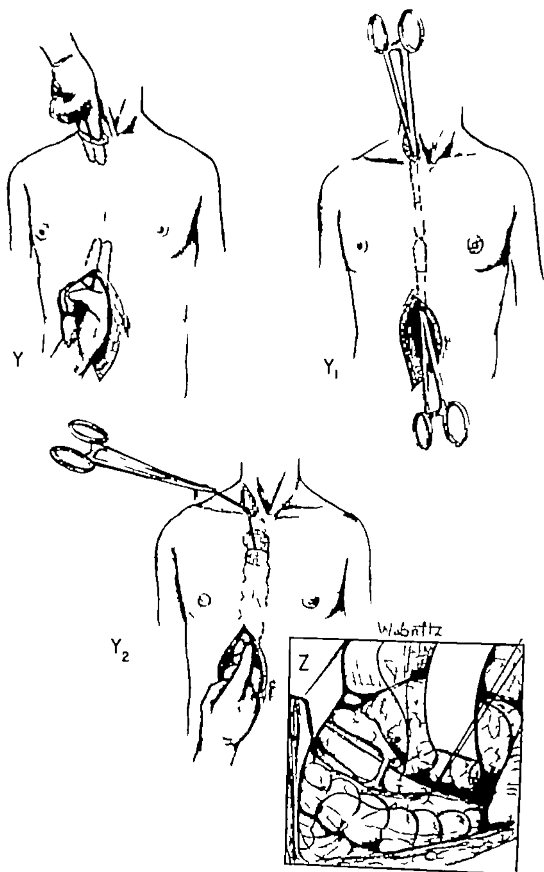

V
V1
V2
V3
V4
W
X

V V_1 On completion of the esophagocolostomy the peritoneal cavity is again entered for the performance of the cologastrostomy A longitudinal opening is made in the anterior wall of the stomach, preferably much closer to the fundus than depicted. Interrupted mattress sutures are used for the first posterior layer (V) and interrupted through-and-through sutures for the second layer posteriorly (V_1)

V_2, V_3, V_4 The sutures that comprise the first anterior layer (V_2, V_3) are inserted as previously described and terminate in the center of the anastomosis (V_3) A series of Halsted mattress sutures is used to complete the serosal layer anteriorly (V_4)

W This view of the peritoneal cavity shows the completed abdominal portion of the operation and the relation between the end-to-side cologastrostomy and the end-to-end ileotransverse colon colostomy

X. This inset shows the completed esophagocoloplasty The abdominal, thoracic, and cervical incisions are depicted, and the esophagocolic, the cologastric, and ileocolic anastomoses are illustrated in broken outline


Y
Y1
Y2
Z

In the transplantation of the colon to the cervical region, the substernal extrapleural route is preferred by many This route is shorter than the transpleural, and in the event of infection secondary to leakage of the anastomosis, the morbidity and mortality are lessened.

Y By concomitant blunt digital dissection through the cervical and abdominal incisions a tunnel is initiated in the substernal tissue plane

Y_1 The dissection is continued with moist gauze sponges held in sponge stick forceps to complete the substernal tunnel

Y_2 The colon is transplanted from the peritoneal cavity into the substernal tunnel and cervical region by gentle taxis from below and traction from above as illustrated

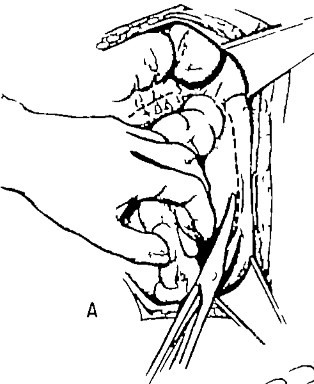
Z. This inset shows the fixation of the mesentery of the transplanted colon to the mediastinal pleura in those patients in whom the transpleural route is used to transplant the colon into the cervical incision

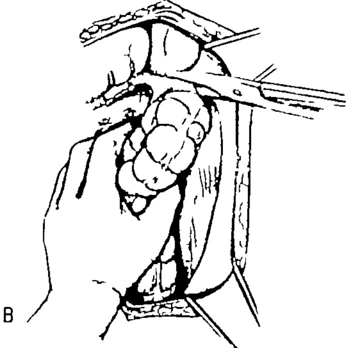
Discussion—Dr. Mahoney (cont.)

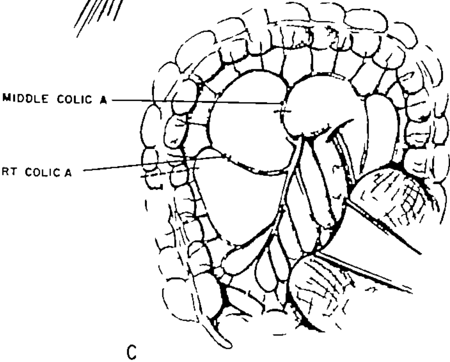
Y and Z show anastomosis of the transplant to the esophagus above the clavicle. It has been my experience that frequently the proximal end of the transplant, at this stage, will show some edema and duskiness If this occurs, the anastomosis is not performed at this stage. The proximal end of the esophagus and the transplant are brought out *through the incision in the neck, and the procedure* is terminated Usually the edema of the transplant subsides after four to seven days, and at this time normal color has returned and the anastomosis is performed as a secondary procedure. Particular care must be taken with this anastomosis, and I prefer interrupted fine silk throughout.

The second operation illustrated depicts utilization of the transverse colon with the splenic and hepatic flexures as a transplant. I have used the transverse colon for short bypass procedures, particularly in those situations where only the terminal esophagus is to be resected. If the left colon is to be utilized for a long transplant, we prefer the descending colon and sigmoid brought up as an antiperistaltic loop

It should be emphasized that the anatomy varies considerably with each individual and that the surgeon must approach this procedure with an open mind as to the type of technic which shall be used. No hard and fast rules can be laid down as to the exact procedures to be followed, and frequently the surgeon must tailor the operation to meet the individual situation


A

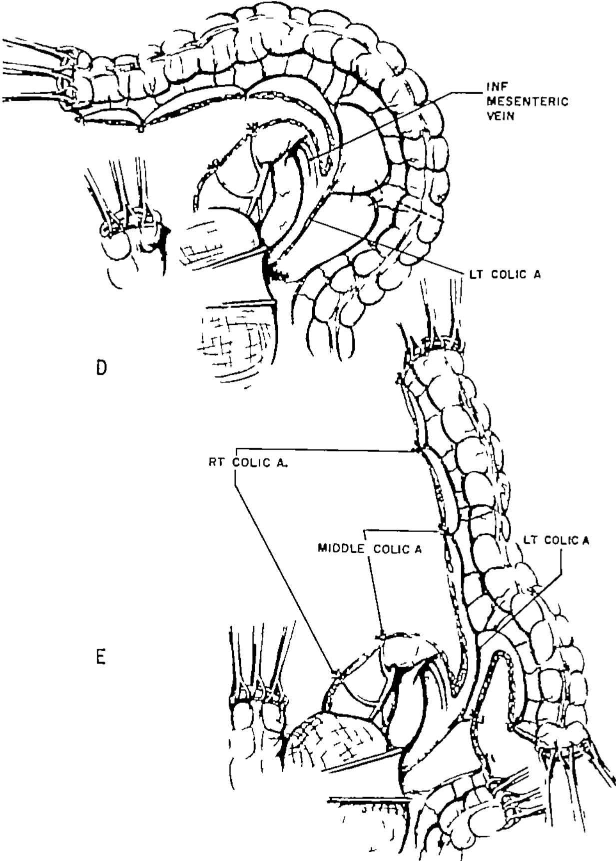

B


MIDDLE COLIC A
RT COLIC A
C

A. In some patients, particularly those in whom extra length of colon is required, the use of the left colon is frequently preferred. Mobilization of the left colon is begun by scissor dissection along the fascia fusion layer of Toldt and is indicated by the broken line (A) Next the lesser sac is entered cephalad to the transverse colon, serially clamping and severing the gastrocolic ligament (broken line)

B. The entrance into the lesser sac permits the approximation of the transverse and descending colons, which facilitates the application of manual traction downward as the phrenocolic and splenocolic ligaments are severed with scissors.

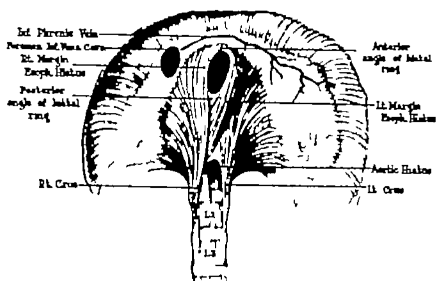
C. The blood supply to the right side of the colon, the transverse colon and splenic flexure is depicted. The broken lines indicate the sites of severance of the middle colic and right colic arteries and the ascending colon In this specimen the viability of the excluded colon segment will be maintained by the left colic artery through the marginal artery

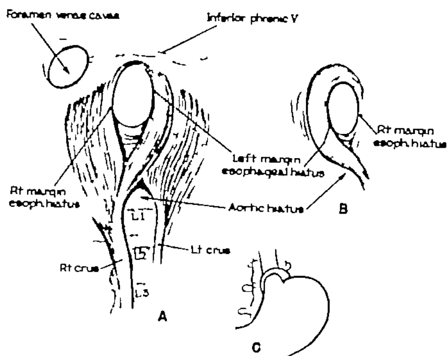

INF
MESENTERIC
VEIN
LT COLIC A
D
RT COLIC A.
MIDDLE COLIC A
LT COLIC A
E

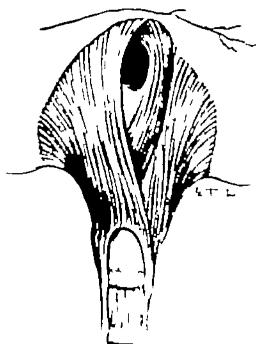
D The right colic and middle colic arteries are severed, and the transected ends of the ascending colon are occluded by Babcock clamps modified on the Potts principle.* The broken lines indicate the sites for transection of the remaining blood vessels and bowel to complete the mobilization of the left colon for transplantation.

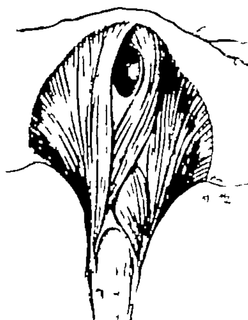
E. The excluded colon segment and its blood supply maintained through the marginal artery by the left colic artery are depicted. The intact inferior mesenteric vein is also visible

* Manufactured by Edward Weck & Co. Long Island City NY




Foramen venae cavae
Inferior phrenic V
Rt margin
esoph. hiatus
Left margin
esophageal hiatus
Rt margin
esoph. hiatus
Aortic hiatus
L1
L2
L3
Lt crus
Rt crus
A
B
C





THE TRANSTHORACIC REPAIR OF AN ESOPHAGEAL HIATUS HERNIA

TOP

Artist's illustrations of the inferior or abdominal aspect of the diaphragm drawn from a fresh cadaver specimen. The right crus, longer thicker and more tendinous than the left, separates into superficial and deep muscle bundles to form completely the esophageal hiatus The superficial layer forms the right margin and the deep layer the left margin of the hiatal ring, effecting a slinglike arrangement of the fibers of the right crus The close relation of the tendinous portion of the diaphragm and the inferior phrenic vein to the anterior angle of the hiatal ring is depicted.

MIDDLE

A. Artist's interpretation of the anatomy of the esophageal hiatus drawn from a fresh cadaver specimen showing the esophageal hiatus from the abdominal view The formation of the hiatal ring or sling by the muscle fibers of the right crus is depicted. The greater length and width of the right crus compared to the left are demonstrated.

B. The esophageal hiatus as it appears looking obliquely downward from the head of the cadaver specimen. The thick or deep layer of muscle fibers of the right crus which forms the left margin of the hiatal ring lies superficial to and crosses the superficial or thin layer of muscle fibers of the right crus which forms the right margin of the hiatal ring.

C. Diagrammatic representation of the sling like arrangement of the muscle fibers of the right crus of the diaphragm in the formation of the esophageal hiatal ring.

BOTTOM

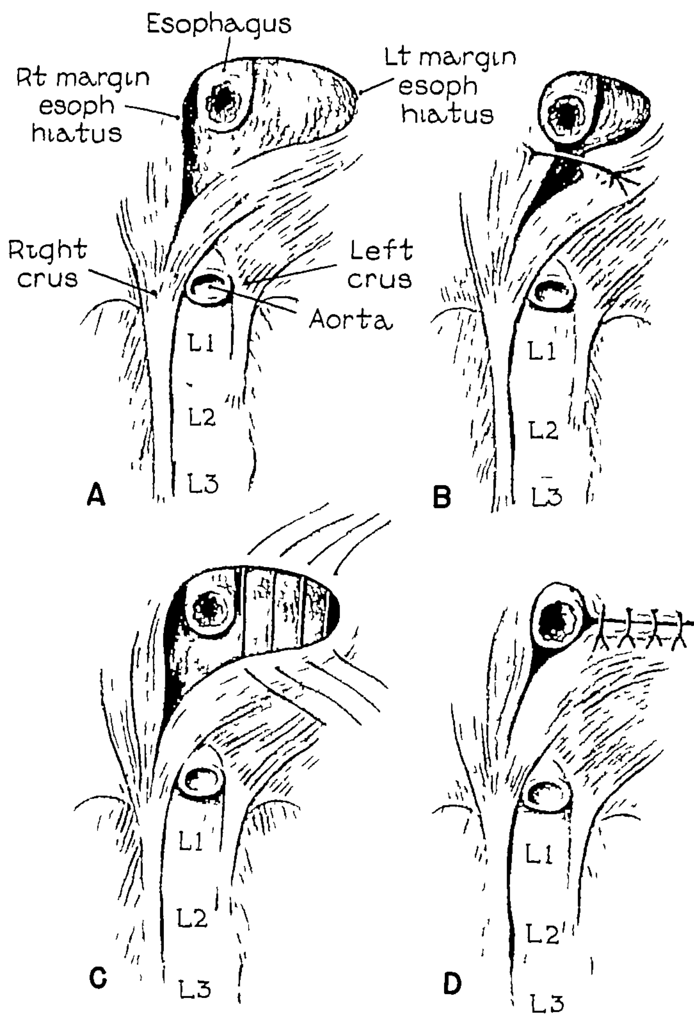
These two artist's illustrations were drawn from fresh cadaver specimens and show the variations in the anatomy of the esophageal hiatus from that previously described.

Left. The muscle fibers of the left crus are separated into superficial and deep layers. The fibers of the superficial layer cross over the deep layer of muscle fibers of the right crus, and join with the fibers of the superficial layer of the right crus to form the right margin of the esophageal hiatal ring.

Right. In this specimen a thick bundle of muscle fibers from the left crus crosses beneath the deep layer of fibers of the right crus and ultimately blends with the superior or thoracic surface of the superficial layer of muscle fibers of the right crus This particular anatomic configuration was originally described by Low and the crossing bundle of fibers of the left crus is commonly called the band of Low

DISCUSSION—DR. PAUL C. SAMSON The first plate illustrates two facts of great importance (1) the esophageal hiatus nearly always comprises muscles fibers from the *right* crus of the diaphragm, (2) the hiatus is oval, with the long axis in a generally anteroposterior direction. The anterior angle is rounded and firm, the posterior angle is usually the "weak spot" and is formed by the crossing or decussation of muscle fibers from the right (or medial) and left (or lateral) margins of the hiatus.

Illustrations A through U depict a method of transthoracic repair that differs in several details from the one I usually employ In D resection of the eighth rib is acceptable and may give more room without undue spreading of the ribs. In E, there is no point in injecting the left phrenic nerve. In fact, I think it is contraindicated. The anesthesiologist can easily control diaphragmatic motion during operation. In addition, I have seen hours and days of phrenic paralysis from injection alone. In F the label should read simply *pulmonary ligament* since there is no *inferior* pulmonary ligament Regarding H and I, careful dissection of the esophagus is necessary but the vagi should *not* be separated from the esophagus and should not be put on great tension. A drain passed around the esophagus should include both vagus nerves. Also, I carefully free the muscle fibers of the right crus circumferentially from the hernial sac for a distance of 6 or 7 mm., which prevents a "rolling in of the muscle when the hernia is reduced. In J my counterincision is longer and roughly parallels the curve of the left (lateral) margin of the hiatus. This is because I believe strongly in Allison's method of tacking remnants of the sac, phrenoesophageal ligament and peritoneum to the under surface of the diaphragm (see B) Regarding K, L, and M I do not *excise* any portion of the sac, but with a wide horizontal (anteroposterior) incision a generous cuff is left attached to the region of the esophagogastric junction. From four to six, spaced, 000 silk sutures taken in the cuff at this stage are later passed through the counterincision, reneedled, and sewn to the undersurface of the diaphragm approximately 7 to 10 mm. from the left margin of the hiatus. In passing, I must confess that most illustrators make the phrenoesophageal ligament much more easy to identify than I am frequently able to do at the operating table. In O since the anterior rounded "angle" of the hiatus usually is firm, I doubt if I employ sutures at the anterior angle in more than 10 per cent of cases. In P and Q the essence of repair is the


Esophagus
Rt margin esoph hiatus
Lt margin esoph hiatus
Right crus
Left crus
Aorta
L1
L2
L3
A
B
C
D

A. The patient is placed in the right lateral prone position and the incision overlying the eighth interspace is outlined.

B C D The incision is deepened through the underlying muscle layers to expose the line of incision in the eighth interspace.

E. The left pleural cavity is entered and the wound margins are retracted with two self retaining rib retractors of the Tuffier type The resection of a rib is not required The phrenic nerve is not crushed by clamping, but temporary paralysis of the diaphragm is obtained by injection of the nerve with 6 to 8 ml. of procaine solution (one per cent). Paralysis of the phrenic nerve by crushing destroys the bellowslike action of the diaphragm which is believed to predis pose to postoperative pulmonary complica tions.

F The deflated left lung is displaced upward and maintained in position by retraction over a moist gauze pad This exposes the characteristic protrusion of the sliding her nia in the esophageal triangle. This triangle is bounded medially (anteriorly) by the pericardium and laterally (posteriorly) by the aorta. The base is formed by the dia phragm and the apex by the proximal por tion of the inferior pulmonary ligament. The inverted T-shaped incision in the mediastinal and diaphragmatic pleura is depicted by the dotted lines. The horizontal portion of this incision extends medially (anteriorly) to the base of the pericardium and laterally (poste riorly) to a point just beyond the thoracic aorta

G The flaps of mediastinal pleura are retracted by guy sutures of silk (000) and the exten sion of the underlying muscle fibers of the diaphragm onto the base of the hernial protrusion may be seen.

Discussion—Dr. Samson (cont.)

posterior closure, where the fibers from the left (lateral) and right (medial) margins of the hiatus frequently appear to decussate. I think medium heavy silk (0 or 1) is better than fine silk. Dr Madden rightly points out that the right marginal fibers are thin, and heavier silk will not cut. In this connection, I always seek to buttress any muscle sutures by passing the needle through pleura, peritoneum, or an available portion of the sac, which frequently I can pull up from below The silk is tied with four throws of the knot. I am sure there have been some recurrences simply because the silk came untied early in the postoperative period. The closure usually needs only two to four sutures. With a Levin tube in the esophagus, the closure should be snug to the passage of the tip of the index finger

In R, the closure of the counterincision must be in two layers, with interrupted silk. In all of the hernias occurring through the counterincision that I personally have seen, either single-layer silk or catgut closures had been employed. R, S, and U show a typical closure for an intercostal incision. When a rib is removed, subperiosteally interrupted silk is used to close the pleural cavity By taking generous bites of intercostal muscle, the intercostal nerve is protected and pain is less. No pericostal sutures are then employed.

I II, and III illustrate well the modification described. As I have stated, I prefer to suture the cuff beneath the diaphragm. This technic is not difficult or time-consuming particularly if the counterincision is a little longer and parallels the left margin of the hiatus. It does mean that there will be several millimeters further reduction of the hernia.

The last two plates nicely illustrate an unusual problem and its solution. I think they emphasize the necessity of accurate anatomic delineation of the entire situation before repair has commenced.

The plates show clearly the steps in the transabdominal repair of an esophageal hiatus hernia. The end result of the repair should be the same as with the transthoracic approach. I may say that there is no uniformity of opinion regarding the method of approach. Some general surgeons believe the transthoracic approach is superior while, conversely some thoracic surgeons, particularly those who now perform a more complicated oper ation as a routine, have switched to the abdominal route. In a given case, complete familiarity with one or the other approaches should be the guiding factor The operation from either aspect is not one of critical proportions, but there are a number of important technical details which must be remembered, and I think it is fair to say that the occasional operator will not have as high a percentage of success, as the surgeon who does the operation frequently

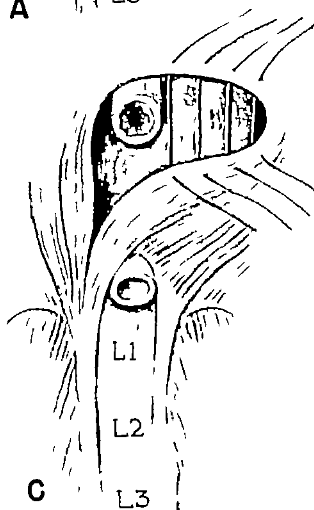
If other abdominal pathologic lesions (possibly requiring surgery) are uncovered during the preoperative workup, then the operation should be peformed from below If however the gall bladder and stomach are not implicated, if the patient is quite fat (as many are) or if other abdominal surgery has preceded the prospective repair then I think there is fairly general agreement that the transthoracic approach is superior

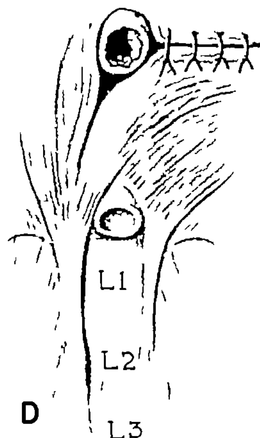
Finally I have encountered a rare situation when with a transthoracic approach, vagotomy and pyloroplasty seem called for In such an instance, I have not hesitated to do the vagotomy through the chest, repair the hernia (if possible) and after closing the thoracic incision, turn the patient supine and perform a pyloroplasty through a separate small abdominal incision.

Plate 85

Esophagus
Rt margin esoph hiatus
Lt margin esoph hiatus
Right crus
Left crus
Aorta
L1
L2
L3
A

L1
L2
L3
B





Allison emphasized the importance of closure of the hiatal ring in a vertical plane posterior to the esophagus. In the succeeding illustrations the difficulty in performing this method of closure when the long axis of the hiatus is in the transverse or horizontal plane is shown.

A The esophageal hiatus viewed from the lower or abdominal surface of the diaphragm. The dilated hiatal ring prior to closure is demonstrated. The long axis of the ring is in a horizontal plane

B The excessive angulation and tension on the suture line and the inadequacy of the closure on attempted approximation of the muscle layers of the right crus in a vertical plane posterior to the esophagus are shown.

C D The muscle fibers of the right crus are approximated in a horizontal plane to the left of the esophagus The closure is adequate and there is a minimum of tension on the suture line

Although in many instances the illustrated technic has proved satisfactory it is believed anatomically unsound The inherent weakness in the method is the suturing of the muscle fibers of the right crus in the reconstruction of the esophageal hiatus.

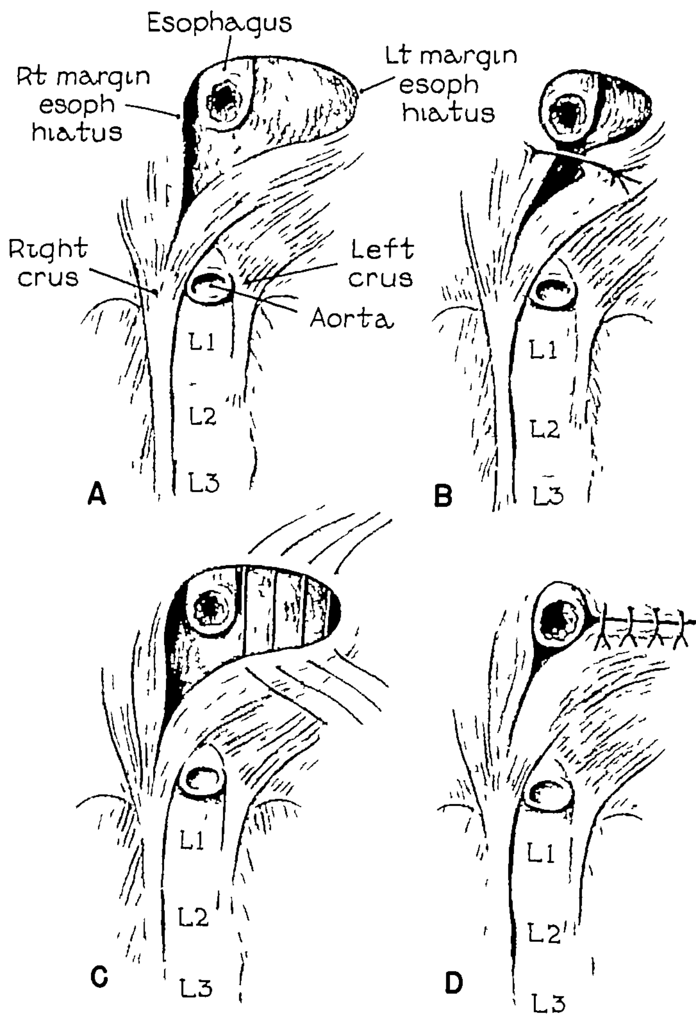
Muscle tissue has a minimal "holding" power for sutures, and, as a consequence, when the muscle contracts, the sutures tear through, even though the tension on the suture line is not excessive. This occurrence has been observed repeatedly during operations, and on several occasions it was necessary to abandon the method

The rationale of attempting to decrease the size of the hiatus is questioned. Frequently in the performance of abdominal operations the hiatus is explored digitally to estimate its size Often it will admit three to four fingers, yet no hernia is demonstrable surgically radiographically or by clinical manifestations On the contrary a hernia may be present in a patient with a relatively small esophageal hiatus Accordingly the size of the hiatus is not the basic factor in the presence or absence of an esophageal hiatus hernia.

If these tenets are accepted—viz. (1) the muscle fibers of the hiatal ring should not be sutured and (2) the presence of esophageal hiatal hernia is not dependent upon the size of the hiatus—the logical question is, What operation should be performed? Admittedly I do not know However it is believed that the sac should always be opened and a flap formed cephalad of peritoneum (sac) and phrenoesophageal ligament (transversalis fascia) The hernia is next reduced, and the flap previously formed is sutured to the pleural surface and tendinous portion of the diaphragm In this manner a firm serosa to-serosa apposition of tissues possessed of good "holding" power is obtained Since the principle of the method is believed of basic importance, anchorage of the flap to the under or peritoneal surface of the diaphragm is not considered necessary In fact, this procedure not only is technically more difficult but also necessitates the apposition of fascia (phrenoesophageal ligament) to serosa rather than the preferred serosa-to-serosa union that is obtained with the technic previously described The union of serosa to serosa is a time-honored principle in intestinal surgery

In some instances the ends of the peritoneal-fascia flaps are sutured together behind the esophagus to form a circular cuff about the esophagocardial junction The lower margin of the cuff is then sutured in a circular manner to the adjacent cut margins of the diaphragmatic pleura and the underlying tendinous portion of the diaphragm. Again serosa-to-serosa apposition is obtained with concomitant fascia reinforcement on each side of the suture line. This technic, from theoretical as well as practical considerations, is preferred.

In each of the technics described the transthoracic route is required Accordingly this route is of necessity preferred Many surgeons elect the abdominal route so that an artificial angle of His may be more easily established by suture of the fundus of the stomach to the undersurface of the diaphragm in juxtaposition to the hiatus The basis for this maneuver is more theoretical than real. What is more important is the reduction of the hernia and the maintenance of its reduction which may be more ably accomplished by use of the transthoracic approach


Esophagus
Rt margin esoph hiatus
Lt margin esoph hiatus
Right crus
Left crus
Aorta
L1
L2
L3
A
B
C
D

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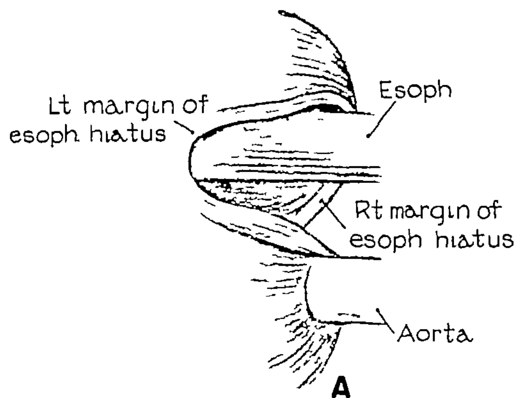
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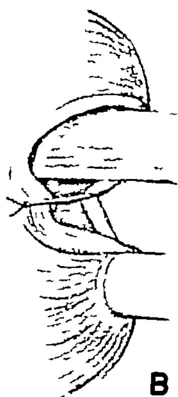
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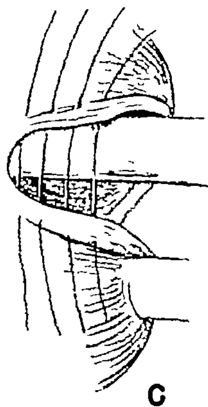
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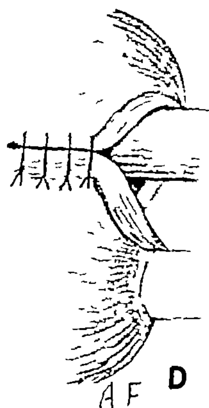
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Lt margin of esoph hiatus
Esoph
Rt margin of esoph hiatus
Aorta
A


B


C


D
AF

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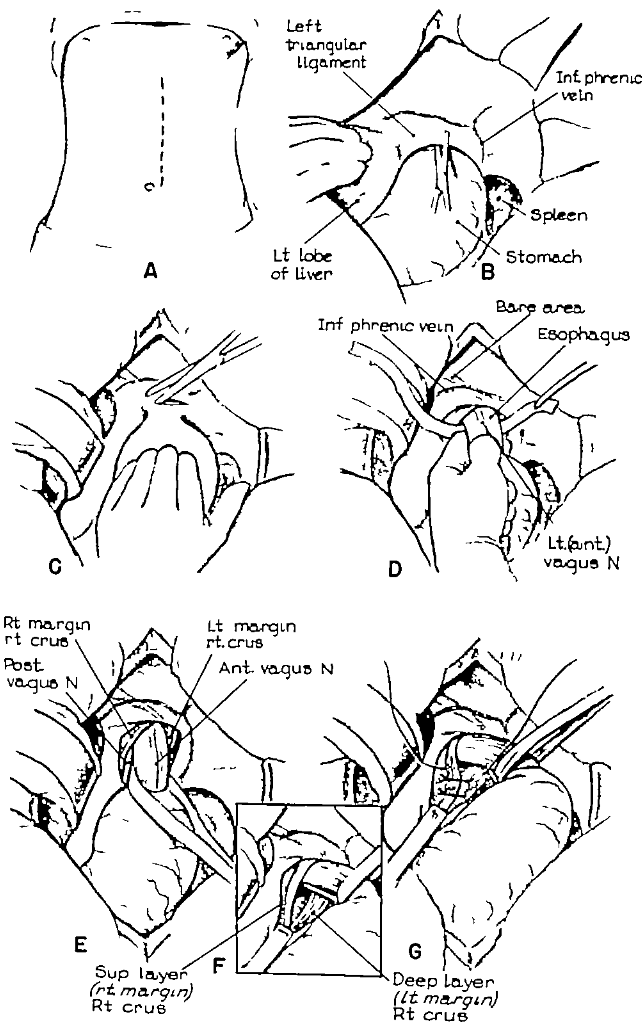
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A
Left triangular ligament
Inf. phrenic vein
Spleen
Stomach
Lt lobe of liver
B
C
Bare area
Inf phrenic vein
Esophagus
Lt.(ant.) vagus N
D
Rt margin rt crus
Lt margin rt.crus
Post. vagus N
Ant. vagus N
E
F
G
Sup layer (rt margin) Rt crus
Deep layer (lt margin) Rt crus

The same illustrations as in Plate 85 when viewed from the upper or thoracic surface of the diaphragm with the patient in the direct right lateral prone position.

A. The thick layer of muscle fibers of the right crus, the left margin of the hiatal ring, crossing superficial to the thin layer of muscle fibers of the right crus, the right margin of the hiatal ring, is shown. The long axis of the hiatus is in the left lateral or horizontal plane

B. The excessive angulation and tension on the suture line and the inadequate closure on attempted approximation of the muscle fibers of the right crus in a vertical plane posterior to the esophagus is demonstrated.

All too frequently artist s illustrations depicting the transthoracic approach for the repair of an esophageal hiatus hernia will show the thoracic incision being properly made with the patient in the right lateral prone position But when the left pleural cavity is entered, the anatomic relations of the hiatal ring and the method for its closure are illustrated as if the patient were supine It is believed that such illustrations are perpetuations of error which have led to needless confusion and misunderstanding of both the anatomy of the hiatal ring and the methods of surgical repair The surgeon should remember that in the transthoracic approach, with the patient in the right lateral prone position, the posterior angle of the hiatal ring is always facing toward him. Furthermore, it is at this angle that the crossing of the fibers of the right crus occurs (A)

Commonly in the transthoracic approach, closure of the hiatal ring in the lateral plane to the left of the esophagus (C) is described as anterior to the esophagus. Similarly closure in the opposite or right lateral plane (D) is described as posterior to the esophagus However a careful study of the comparative relation of the hiatal ring to the esophagus in the supine (Plate 85) and in the right lateral prone positions (Plate 86) should aid in the correction of these anatomic misinterpretations.

DISCUSSION—DR. RICHARD H SWEET The *abdominal approach* for the repair of a hiatus hernia is well illustrated in Plate 87 Here also precise knowledge of the anatomy is absolutely essential In fact, the failures which result from the use of this approach are undoubtedly due to inaccuracy in dealing with the structures involved. As with all surgery a wide exposure of the operative field must be obtained. It is this aspect of the employ ment of the abdominal approach which creates the greatest technical problem.

The incision must be long and must reach upward to the costoxiphoid angle (Plate 87 A) So also the left lobe of the liver must be retracted away from the operative field. This step requires the division of the left triangular ligament and the folding under of the liver edge as shown in Plate 87 (B and C)

It should be stressed also that, with the abdominal approach as with the thoracic, the margins of the hiatus must be exposed to view so that sutures can be inserted in the muscle bundles. This is best accomplished by retracting the esophagus to the left (Plate 87 F and G)

Little remains of the peritoneal sac after the dissection necessary to expose the lower esophagus and the muscle bundles of the right crus has been completed, but nothing much need be done about it. Any redundant edges of peritoneum, however can be trimmed away and the peritoneal layer closed with sutures which attach it to the under surface of the diaphragm as an additional safe guard against recurrence.

THE TRANSABDOMINAL APPROACH FOR THE REPAIR OF AN ESOPHAGEAL HIATUS HERNIA

A. The patient is placed in the supine position, and the incision of choice, a long left paramedian muscle retracting (lateral) incision, is outlined.

B. The peritoneal cavity is entered, and the related intraperitoneal viscera are demonstrable By manual retraction the left lobe of the liver is displaced downward toward the midline, and its mobilization is commenced by the severance of the avascular left triangular ligament In some instances the left lobe of the liver is elongated and the left triangular ligament is markedly foreshortened Under such circumstances the esophagocardial region is exposed by the retraction upward of the left lobe of the liver the surface of which is protected by a moist gauze pad.

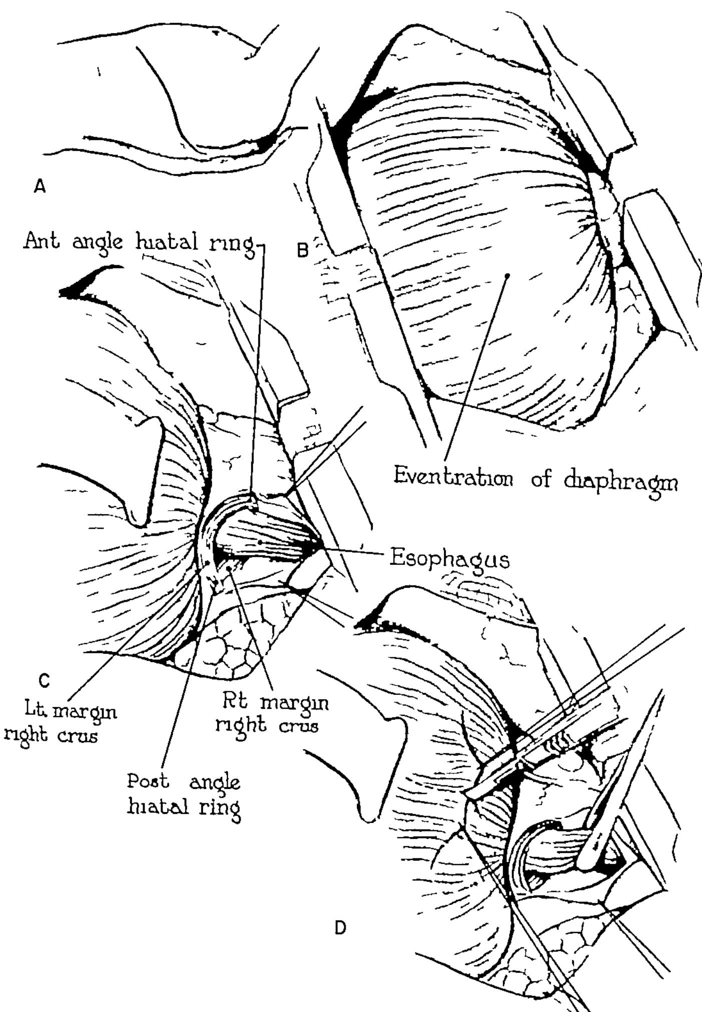
C. The mobilized left lobe of the liver is turned downward and inward on itself and, after being covered with a moist gauze pad, it is retracted medialward. By manual traction the herniated segment of the stomach into the posterior mediastinum through the esophageal hiatus is reduced and the layer of peritoneum overlying the esophagocardial junction is severed by scissor dissection.

D The posterior mediastinal space is entered and the terminal portion of the esophagus, mobilized previously by digital dissection, is encircled by a rubber tissue drain for the purpose of traction.

E. The reduction of the hernia is maintained by downward traction. The terminal 4 cm. of the esophagus is exposed, and its relation to the vagus nerves and the right and left margins of the esophageal hiatus formed by the superficial and deep muscle layers respectively of the right crus of the diaphragm are demonstrated.

F The esophagus is displaced to the left to show the enlarged esophageal hiatus and its formation by the separation of the fibers of the right crus into thin superficial (right margin) and thick deep (left margin) muscle layers.

G. The superficial and deep muscle layers of the right crus of the diaphragm, the right and left margins respectively of the hiatal ring, are approximated in a slightly oblique plane posterior to the esophagus, using two or three interrupted sutures of silk (No. 1). In this approximation, tension on the suture line should be avoided.


A
B
Ant angle hiatal ring
Eventration of diaphragm
Esophagus
C
Lt. margin right crus
Rt margin right crus
Post angle hiatal ring
D

DISCUSSION—DR. DENTON A. COOLEY Indications for the transthoracic or transabdominal approach in the repair of an esophageal hiatal hernia were not part of this presentation, yet this aspect of the technical problem is important and deserves careful consideration After an experience with a sizable series of patients operated upon by both technics, I have concluded that the transabdominal approach should be the procedure of choice. Two exceptions to this policy would be, first, the extremely obese patient in whom surgical exposure in the upper abdomen would be difficult and, second, the patient with a recurrent hernia. Recurrence of an esophageal hiatal hernia is difficult to repair from the abdominal route, since adhesions about the hiatus and herniated stomach located in the mediastinum or pleural space are difficult to divide transabdominally In some of the more complicated recurrences with a history of more than one attempted repair consideration should even be given to a combined thoraco-abdominal incision so the repair can be accomplished from above and below the hiatus.

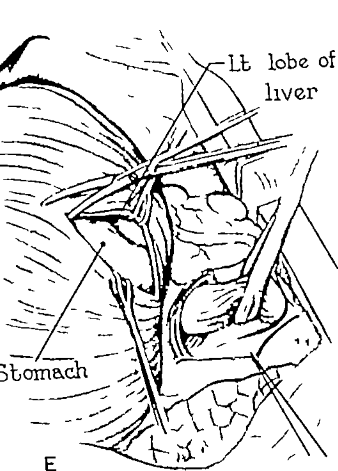
Selection of the transabdominal approach for all other elective situations depends upon a number of factors Exposure of the anatomy about the hiatus is best demonstrated from below Anatomists and artists support this viewpoint, since their descriptions and drawings usually emphasize this surface of the diaphragm. Avoiding the thoracotomy incision also eliminates the intercostal nerve pain or troublesome neuralgia, which may simulate the symptoms caused by the hernia. Efforts to eliminate this postoperative chest pain by technics of reapproximating the ribs, as described by Dr Madden, are helpful but by no means completely effective. Moreover pericostal sutures of heavy silk should probably be replaced by absorbable chromic catgut. The midline abdominal incision is less difficult than a paramedian and is easier to repair Nonabsorbable Dacron or Merslene sutures in the linea alba give a firm repair with a low incidence of incisional hernia.

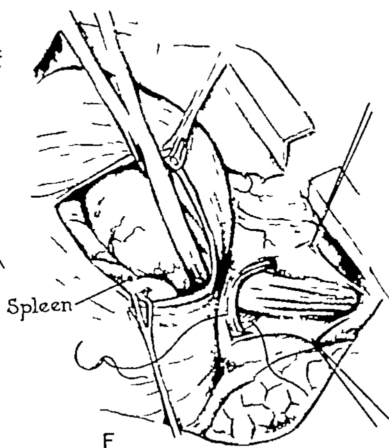
An important step in repair of the lesion is complete reduction of the hernia and withdrawal of the esophagus well down into the subdiaphragmatic position. This can best be accomplished by the vertical downward traction from the upper abdomen with the patient lying supine. Since the muscle fibers of the crus are usually attenuated and friable, interrupted sutures have a tendency to cut through the fibers. Thus, from the transabdominal approach these sutures should be placed through the covering peritoneum for additional support. Repair of the hiatus, in my opinion, should always be done by approximating the fibers of the crus posterior and inferior to the hiatus, leaving the anterior sling unrestricted by plicating sutures. The size of the hiatus should be carefully controlled and should not be too tight because edema may cause dysphagia after operation After the repair the opening should accommodate an index finger easily alongside the esophagus.

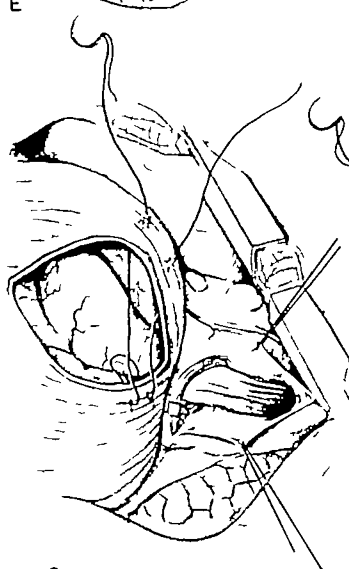
When the hernia is completely reduced, a portion of 2 to 3 cm of longitudinal muscle fibers of esophagus above the esophagogastric junction is visible below the newly repaired hiatus. Usually the phrenicoesophageal ligament, which in my opinion is overrated as a useful structure in the repair of the hernia, is located well down in the abdominal cavity An important part of the repair is placement of a circle of interrupted 000 nonabsorbable sutures, about six or eight in number to anchor the esophagus to the hiatal fibers. Another technical point that may be important is to place a row of interrupted sutures between the gastric cardia and the adjacent esophagus. The maneuver maintains the acute esophagogastric angle that is important to prevent esophageal reflux. The vagus nerves should not be divided or sutured into the repair unless the patient requires additional surgery for peptic ulcer or reflux esophagitis.

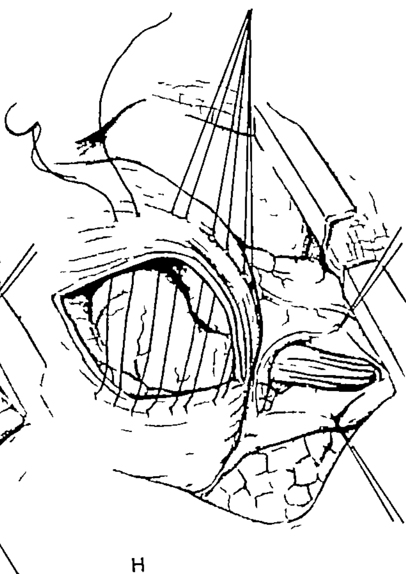
Perhaps the strongest argument in favor of the transabdominal approach is the opportunity afforded for exploration of the peritoneal cavity for additional pathologic lesions. Among the more common associated lesions in my experience were chronic cholecystitis with cholelithiasis and duodenal ulcer Occasionally unsuspected retroperitoneal or intraperitoneal neoplasms have also been discovered they were the actual cause for the patient's symptoms. Routine appendectomy was also employed in our patients.

Plate 89









EVENTRATION OF THE DIAPHRAGM

A. The patient is placed in the direct right lateral prone position, and the incision overlying the eighth rib is indicated by the solid line

B. The elevated left leaflet of the diaphragm which caused a compression atelectasis of the lower lobe of the left lung is shown. Despite the high elevation of the diaphragmatic leaflet, its muscle tone was surprisingly good. No tendinous portion was visible

C The diaphragm is retracted downward, and the flaps of the posterior mediastinal and diaphragmatic pleura are raised to expose the lower portion of the esophagus and the muscular esophageal hiatal ring. This ring is formed by a separation of the muscle fibers of the right crus into two layers, superficial and deep The superficial layer forms the right margin and the deep layer the left margin of the esophageal hiatus. From the thoracic approach as illustrated, the thick layer of fibers which forms the left margin crosses superficial to the thin layer of fibers which forms the right margin of the hiatus The reverse is true when the hiatus is viewed from the abdominal side with the patient supine It should also be observed that with the patient in the right lateral prone position, the posterior angle of the esophageal ring is directed toward the surgeon This anatomic point is stressed because it is so frequently misrepresented in artist s illustrations. In this patient a concomitant finding was a small sliding hiatus hernia.

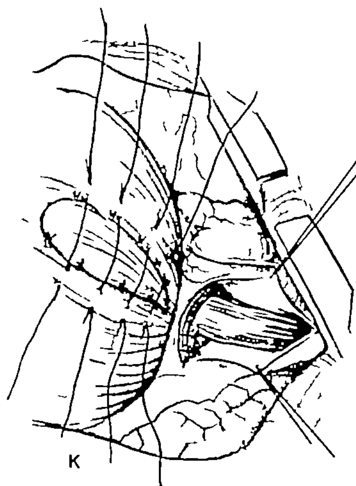
D The lower portion of the esophagus is encircled by a cotton tape for traction, and the left leaflet of the diaphragm, tented by guy sutures of silk (000) is incised. The incision is subsequently extended by scissor dissection as indicated by the dotted line

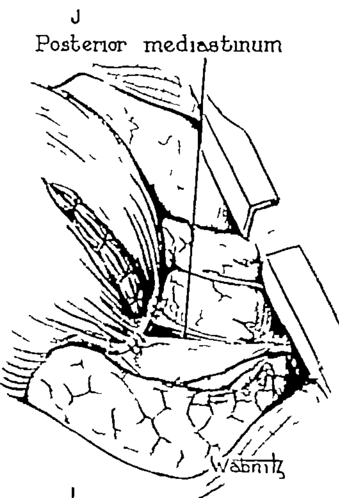
Pericardium

Phrenic N

I

J



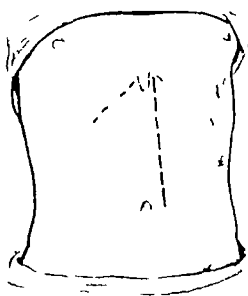


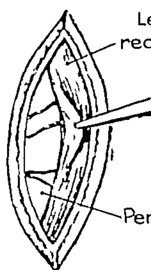
E. The incised margins of the diaphragm are grasped in Babcock clamps and the scissor dissection is continued Underlying portions of the stomach and the left lobe of the liver are visible

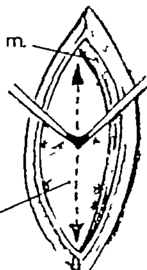
F The long ends of the cotton tape which encircle the lower portion of the esophagus are passed through the hiatus into the peritoneal cavity and then through the opening in the diaphragm into the left pleural cavity By traction on the tape the small herniated segment of the stomach is reduced, and the closure of the hiatal ring posteriorly is begun by the insertion of a suture of No 1 silk. In this illustration the anterior border of the spleen is visible.

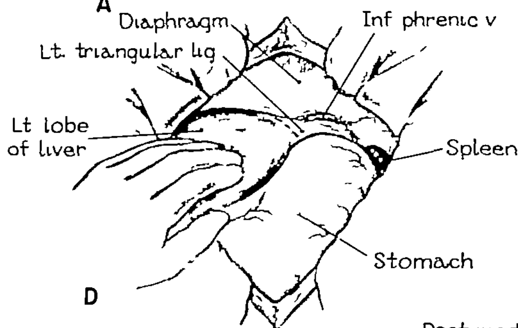
G. The closure of the hiatal ring posteriorly using two interrupted sutures of silk (No 1) is completed, and the insertion of the imbricating mattress sutures of silk (0) for the repair of the eventration of the diaphragm is begun.

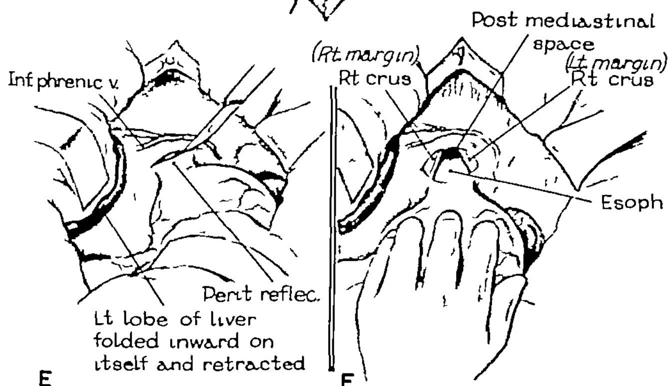
H. All but one of the imbricating mattress sutures are inserted The insertion of these sutures is begun farther from the incised margin of the diaphragm anteriorly than posteriorly so that, when they are tied, an overlap (imbrication) of the cut margins of the diaphragm is obtained.

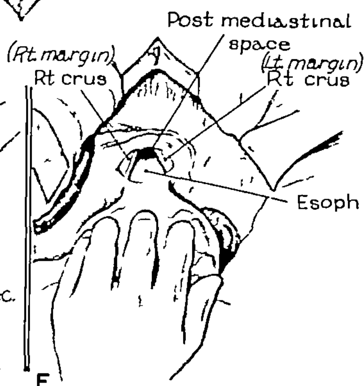

A


Left
rectus m.
Perit
B


C


Diaphragm
Inf phrenic v
Lt. triangular lig
Lt lobe
of liver
Spleen
Stomach
D


Inf phrenic v.
Perit reflec.
Lt lobe of liver
folded inward on
itself and retracted
E

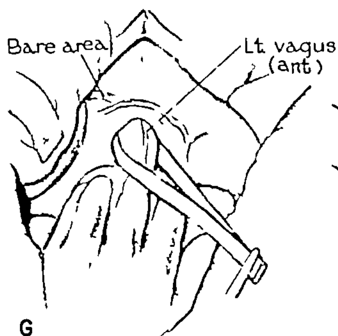

Post mediastinal
space
(Rt margin)
Rt crus
(Lt margin)
Rt crus
Esoph
F

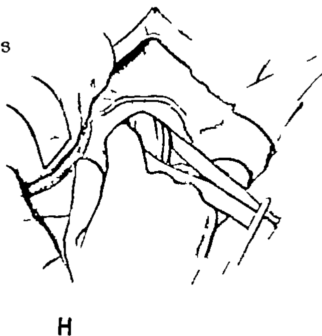
I. The imbricating mattress sutures of silk are tied, and the excess of the overlapping portion of the diaphragm is excised as indicated by the dotted line.

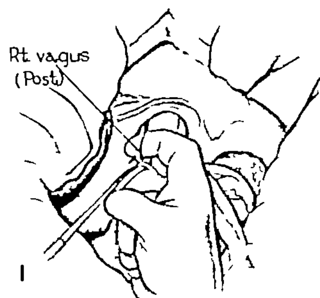
J The free cut margin of the overlapping portion of the left leaflet of the diaphragm is sutured to its subjacent portion with interrupted sutures of 0 silk.

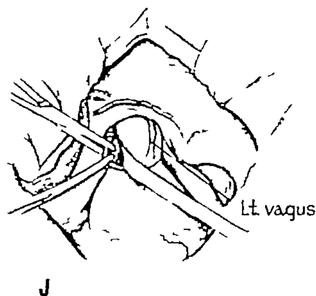
K, L. In this patient some laxity of the diaphragm persisted following the repair as depicted. Accordingly a secondary inversion layer of interrupted sutures of 0 silk was first inserted (K) and the sutures then were tied (L) Following the completion of this procedure the relation of the left leaflet of the diaphragm to its opposite side and to the adjacent intrapleural structures appeared normal The lower lobe of the left lung was easily expanded to its full capacity and the flaps of diaphragmatic pleura were approximated with interrupted sutures of silk (000). The flaps of posterior mediastinal pleura were not sutured. Accordingly in the event of an infection a complicating pleural empyema which is easily drained rather than a mediastinal abscess which is difficult to drain would most likely occur

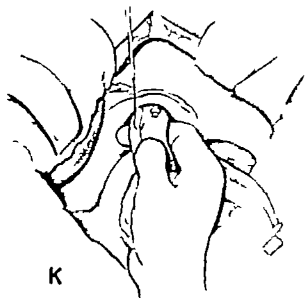
This patient, a 63-year-old obese white man, was admitted to the hospital because of massive gastrointestinal bleeding. A gastrointestinal series revealed a true "upside-down" stomach associated with a high elevation of the left leaflet of the diaphragm as depicted in the illustrations The summit of the elevation was at the level of the third rib anteriorly Because of the severity of the hemorrhage and the previous history of symptoms consistent with the diagnosis of a duodenal ulcer operation was advised. Although the relation of the esophagocardial junction to the hiatal ring appeared normal in the roentgenograms, at operation there was an associated small esophageal hiatal hernia of the sliding variety In addition to the surgical correction of the eventration of the diaphragm as illustrated, a transdiaphragmatic antecolic gastrojejunostomy in conjunction with a transthoracic partial resection of the vagus nerves was done Postoperative roentgenograms of the chest revealed normal position and mobility of the left leaflet of the diaphragm

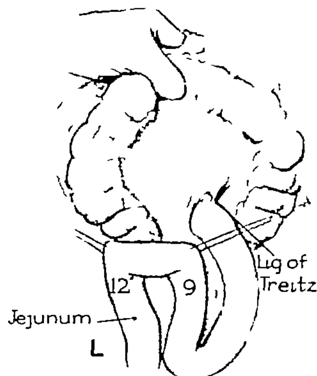

Bare area
Lt. vagus
(ant)
G


H


Rt. vagus
(Post)
I


Lt. vagus
J


K


Lig of
Treitz
12
9
Jejunum
L

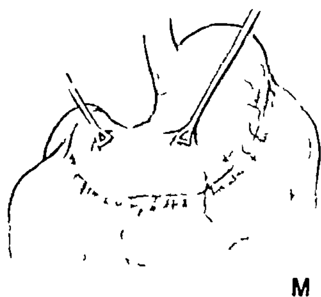
[illegible]MATIC RESECTION OF THE VAGUS NERVES AND ANTECOLIC GASTROJEJUNOSTOMY

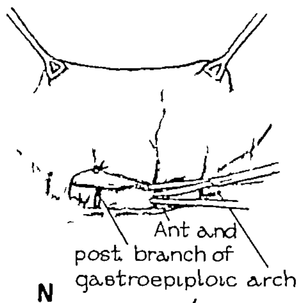
A, B, C The peritoneal cavity is entered through a left paramedian muscle-retracting (lateral) incision

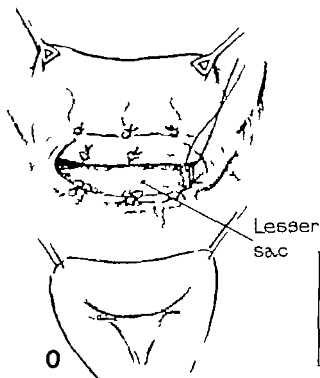
D The wound margins are retracted, and the structures in the region of the esophago-cardial junction are shown The site of severance of the avascular left triangular ligament is shown in dotted outline In some instances this ligament may be too short to sever Under such circumstances, a moist protective pad is placed beneath the left lobe of the liver which is gently retracted upward

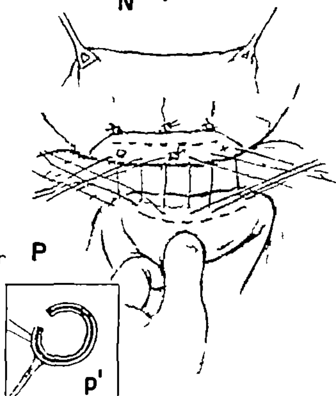
E, F An incision is made through the peritoneal and fascia layers overlying the lower most portion of the esophagus and the posterior mediastinal space is entered. The relation of the esophagus to the margins of the right crus of the diaphragm which form completely the esophageal hiatal ring is shown.

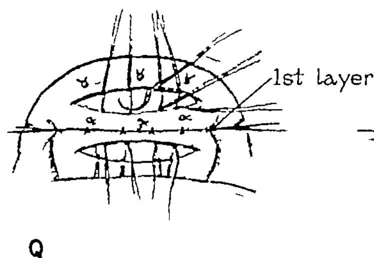
DISCUSSION—DR LESTER R DRAGSTEDT In the transabdominal approach for resection of the vagus nerves, it has been my usual practice to divide the triangular ligament to the left lobe of the liver, illustrated in D Plate 91 I believe that this give[illegible] ter access to the lower portion of the esoph[illegible] However some surgeons of experience, inclu[illegible] Dr Joseph Weinberg of Los Angeles, omit th[illegible] and retract the left lobe of the liver upward with a large broad blade retr[illegible] entering the medias-tinum, I have found it v[illegible] the opening mid-way between the esop[illegible] atus and the large inferior phrenic vein, [illegible] ed in the illustra[illegible] ions E and F Plate 91 [illegible] ly do this by pick[illegible] up the diaphragm [illegible] s with protruding [illegible] making a small [illegible] ir of scissors.

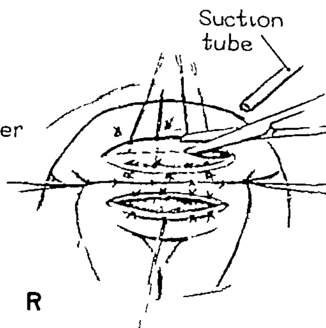

M


Ant and
post. branch of
gastroepiploic arch
N


Lesser
sac
O


P
p'


1st layer
Q


Suction
tube
R

…er end of the esophagus is mobilized digital dissection and encircled by …issue traction tape The left anterior …rve which is always in close relation …nterior surface of the esophagus is

…sophagus is displaced to the left by and the right or posterior vagus …cated in the fibroareolar tissue … and medial to the esophagus is d on the right index finger and …on a nerve hook.

…t (posterior) vagus nerve is divided …sors between a silver clip marker …d a clamp below

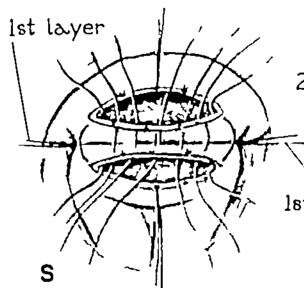
K. The left (anterior) vagus nerve is similarly divided, and careful digital exploration of the periesophageal region for additional nerve fibers is being performed. This is considered a most important part of the operation. A minimum of 3 and a maximum of 13 additional nerve fibers have been identified by this maneuver

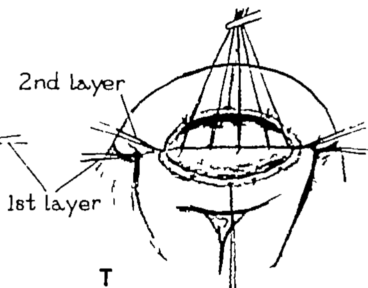
L. The duodenojejunal junction at the base of the transverse mesocolon, as indicated by the ligament of Treitz, is visualized, and a segment of jejunum, 9 to 12 inches distally is isolated by two guy sutures of silk.

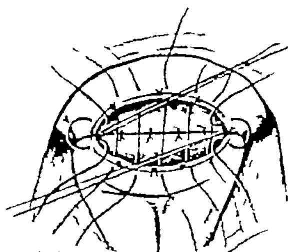
—Dr. Dragstedt (cont.)

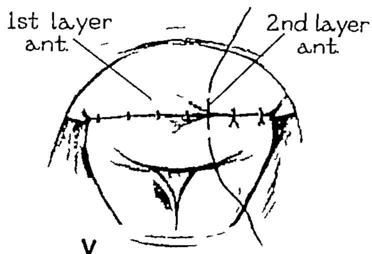
…ig the scissors into the mediastinum, thus …e opening Sometimes I think this may …lesome hemorrhage.
…ing the esophagus by blunt finger dissec… portant to emphasize that this be done …ral cases have been reported where the …has been opened with rough handling. …lization of the esophagus it is my prac… …p the fingers of the right hand around …s in an effort to include all of the vagus …i their grasp The esophagus and vagus …hen pulled downward into the abdomen the posterior vagus nerve, which is felt …yielding esophagus, is pulled over to the …gment excised between ligatures of non-…suture material. The use of silver clips is …sfactory
…ojejunostomy rather than pyloroplasty is …a drainage procedure, I believe it is wise …gastroenterostomy stoma within five or …e pylorus We have encountered a num-…its where a high-lying gastrojejunostomy failed to drain adequately the antrum of the stomach, and the stasis of food in this area caused an excessive secretion of gastric juice of humoral or hormonal origin. It has also been my practice to make a small gastroenterostomy opening so that when the operation is completed the stoma is approximately one and-one half cm. in diameter It is my conviction that such a small stoma decreases the incidence and severity of the dumping syndrome

The transthoracic approach for division of the vagus nerves, such as indicated in the illustrations of this operation, was the method that I first employed. However this operation has been very largely abandoned by me because it does not provide an opportunity to add a drainage procedure to the vagotomy it does not permit inspection of the ulcer and possible associated pathology and because of the frequency of postoperative intercostal pain. This approach, however may be used for the treatment of recurrent gastrojejunal ulcers after repeated gastric resection and possibly in some other special situation.

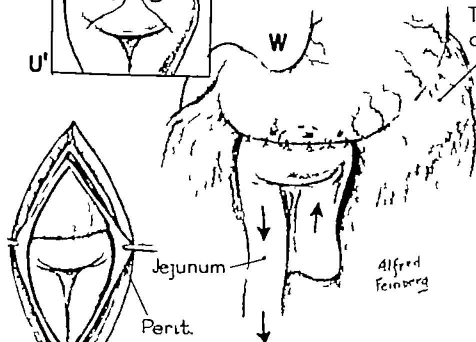

1st layer
S

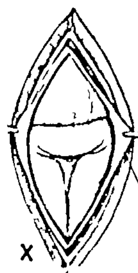

2nd layer
1st layer
T

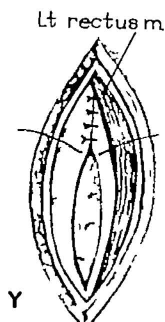

U


1st layer
ant.
2nd layer
ant.
V


U'


W
Trans
colon
Jejunum
Alfred
Feinberg


Perit.
X


Lt rectus m.
Y

M N A segment of the anterior wall of the stomach in juxtaposition to the most dependent portion of the greater curvature is mobilized by Babcock clamps, and the anterior gastric branches of the gastroepiploic arch are serially clamped, severed, and ligated.

O The anterior and all but one of the posterior gastric branches of the gastroepiploic arch have been severed and ligated, and the lesser sac is entered.

P The segment of jejunum previously isolated is brought anterior to the transverse colon and approximated to the posterior wall of the greater curvature of the stomach by a series of interrupted silk (000) sutures. If preferred, the jejunum may be brought through an opening in an avascular portion of the transverse mesocolon and a "short loop" retrocolic gastrojejunostomy performed. The sites of incision in the jejunum and in the avascular plane of the greater curvature of the stomach are indicated in dotted outline No clamps are used in the performance of the anastomosis. This is the preferred technic.

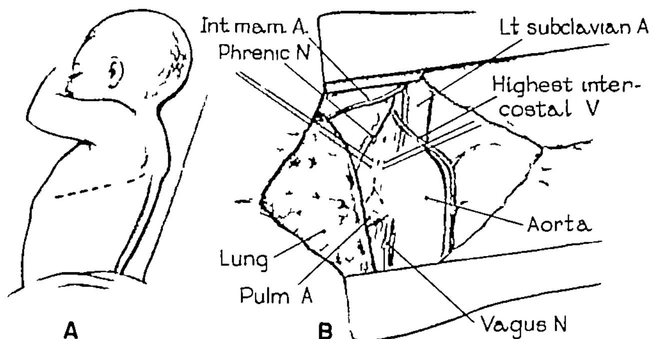
P Inset to show the relation of the first posterior layer of sutures to the mesenteric border of the jejunum.

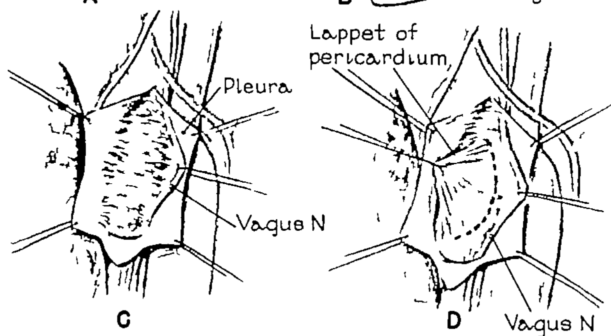
Q Incisions are made through the seromuscular layers of the jejunum and the greater curvature of the stomach, and the vessels in the submucosal layers are undersewn with hemostatic suture ligatures of silk (0000)

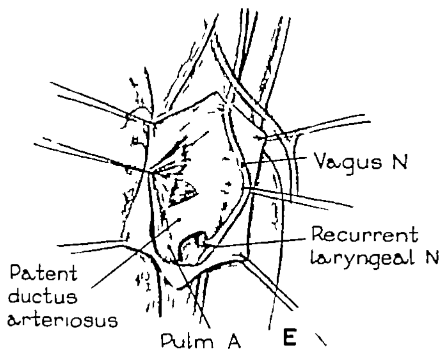
R. The lumen of the stomach is first entered by an incision with a scalpel, and the opening is extended by scissor dissection. The opening, similarly made previously into the lumen of the jejunum, is visible. Soiling of the operative field with either gastric or jejunal contents is minimized by aspiration with the suction tube

DISCUSSION—DR. STANLEY O HOERR. I prefer a midline incision that will extend to the left of the xiphoid and, if necessary to the left of the umbilicus (A, B C) It is very important for ease of exposure to go as high as possible. A self-retaining retractor of the Balfour type may be used instead of hand-held retractors (D) Exposure of the diaphragmatic reflection at the cardioesophageal may be obtained by a ribbon or malleable retractor elevating the left lobe of the liver in my experience, division of the left triangular ligament is rarely necessary

Instead of tugging on the esophagus with an encircling rubber tape or catheter (G H, J) I employ traction on the stomach to make the nerve stand out like a bowstring. The first assistant is instructed to pull the stomach (grasped through a gauze pad) toward the left great toe of the patient. The surgeon may wish to do this first himself using his right hand, while with his left forefinger he palpates the nerve. While palpating the nerve, he transfers the stomach to his assistant who maintains the same degree of traction. A long nerve hook with a right-angle tip (rather than a curved one as shown in I and K) may be used to break through the overlying thin layer of peritoneum, thus omitting the stages shown in E and F A second nerve hook may be used to free up a segment of nerve for easy division and removal of a segment for the pathologist. Sometimes the nerve trunk, particularly the posterior trunk, is accompanied by a small blood vessel, both cut ends should then be clipped or ligated (J) After division of the main trunks, the operator standing on the right side of the patient may encircle the esophagus with his *left* forefinger permitting the surface to be inspected for additional fibers. The posterior (right) vagus nerve at the level of the cardioesophageal junction may be a centimeter or more posterior to the esophagus, and characteristically overlies the aorta, coursing slightly to the left as it descends. Sometimes elevating the stomach slightly (toward the ceiling) while maintaining traction toward the feet will facilitate exposure of this trunk. Inexperienced surgeons may easily overlook even a sizable posterior vagus nerve. Reconstruction of the hiatus may be done after severance of the nerves but is rarely indicated. An exception may be the coexistence of an hiatus hernia believed to be symptomatic.


Int mam A
Phrenic N
Lt subclavian A
Highest inter-costal V
Aorta
Lung
Pulm A
Vagus N
A
B


Pleura
Vagus N
Lappet of pericardium
Vagus N
C
D


Vagus N
Recurrent laryngeal N
Patent ductus arteriosus
Pulm A
E

S. The middle hemostatic sutures on the anterior cut margins of the jejunum and stomach respectively are left long for traction, and the second posterior layer of interrupted sutures of silk (0000) are inserted. No complications have ensued from the use of silk sutures for the mucosal layer In fact, this method of suture is preferred to the use of a continuous interlocking suture of fine chromic (00) catgut.

T The closure of the second posterior layer is completed with a wide approximation of the adjacent posterior serosal surfaces.

U The first anterior layer of silk sutures (0000) are inserted The sutures at either angle are inserted from the "inside out" to the "out side in" and are tied as oblique traction is maintained on the angle sutures of the second posterior layer This type of suture produces an inversion of the serosal surfaces with the suture knot on the inside of the lumen.

U Inset to show the use of interrupted inversion sutures throughout for the closure of the first anterior layer

V The closure of the first anterior layer with single through and through interrupted silk sutures is completed and the insertion of the second anterior layer of interrupted seromuscular sutures (Lembert) of fine silk (0000) is begun.

W The antecolic, isoperistaltic gastrojejunostomy along the most dependent portion of the greater curvature of the stomach is completed.

X, Y The commencement of the wound closure, using interrupted sutures of silk (00) for the peritoneum is shown. If preferred, interrupted silk sutures of the mattress variety or a continuous chromic catgut (00) suture that is doubled, may be used. The fascia and skin layers are closed with interrupted sutures of 00 and 000 silk respectively

Discussion—Dr. Hoerr (cont.)

The ligament of Treitz should invariably be identified directly (L) After selecting a suitable segment of jejunum—as close as possible to the ligament of Treitz without creating tension at the proposed site of the anastomosis—the proximal end of the segment may be grasped with a "soft" Allis clamp (teeth filed off to avoid injury to the bowel) and the distal end of the segment may be grasped by a Babcock clamp. Since A comes before B in the alphabet, the mnemonic A for Allis and B for Babcock will identify the proximal and distal jejunum and may help avoid confusion once the ligament of Treitz is no longer in view

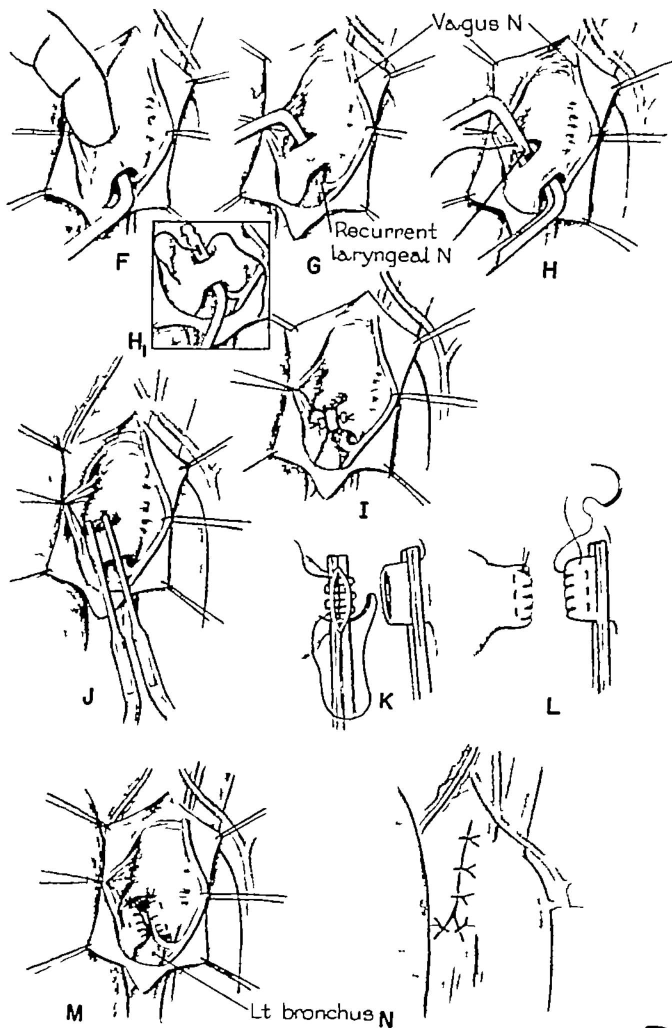
The use of the greater curvature for the gastric stoma (M, N O) is very sound practice and permits accurate placement at the most dependent portion of the stomach. I refer to this as an antecolic dependent gastrojejunostomy rather than as an anterior gastrojejunostomy which may be interpreted as being to the anterior surface of the stomach.

The figures show proximal jejunum to the left of the anastomosis. Ordinarily this will be the more "comfortable" from a mechanical standpoint. The surgeon should not hesitate, however to turn the jejunum in the opposite direction if this would seem to be more free of undesirable kinks or twists.

Interrupted silk sutures for both layers make an excellent anastomosis I personally employ two layers of continuous 00 chromic catgut on an atraumatic needle, with emphasis on the bites being sufficiently deep into muscularis but creating minimal inversion with the outer layer The end result with either suture material seems to be the same, but a continuous suture is a little faster Nonabsorbable materials such as silk and cotton are not suitable for continuous sutures.

If a midline incision has been used, interrupted No 30 stainless steel wire is a convenient mass suture for the deep layers.

The surgeon should utilize antecolic dependent gastrojejunostomy as shown in these figures when feasible, but in an occasional patient with a long transverse mesocolon and a heavy omentum, a posterior gastrojejunostomy may be simpler It is best to remain openminded as to the type of gastrojejunostomy until the exact situation in the given patient has been assessed.


Vagus N
Recurrent laryngeal N
F
G
H
H1
I
J
K
L
M
Lt bronchus
N

PATENT DUCTUS ARTERIOSUS

A. The surgical approach for the ligation or severance of the patent ductus arteriosus may be through either an anterolateral or a direct lateroposterior incision as demonstrated. Although both have been used, the lateroposterior originally suggested by Harrington for operations upon the patent ductus, is preferred.

B. The pleural cavity is entered through either the fourth or fifth interspace, preferably the fourth. The visible structures are depicted The inverted Y incision in the mediastinal pleura, midway between the phrenic nerve anteriorly and the vagus nerve posteriorly is shown in dotted outline

C. The mediastinal pleural flaps are retracted by guy sutures of silk (000) to expose the underlying fibroareolar tissue layer and the vagus nerve, which is retracted by an encircling ligature of silk (000) In some in-stances, although not necessa ticular patient, ligation and se highest intercostal vein may b

D The lappet of pericardium ov gion of the patent ductus is h traction suture of silk (000), p its dissection from the anteron of the aorta as indicated by th dotted line

E. The dissection of the perica completed, and the anterior inferior surfaces of the pater clearly exposed. In this disse portant landmark for the ide the ductus is the recurrent lary of the vagus nerve which cou the inferior border of the ductu end and then continues upwar arch of the aorta into the neck

DISCUSSION—DR. HERBERT C MAIER. In our opinion, the posterolateral incision is preferable because of the better exposure it affords should any difficulty arise during the intrathoracic manipulations. The upper posterior end of the incision can be kept surprisingly low in children and yet permit ready access to the fourth or fifth interspace in females, this lower scar may be of considerable cosmetic importance in later life The midportion of the incision should be below the tip of the scapula An interspace incision without any rib section is adequate in children provided the incision is carried anteriorly to a sufficient extent. The incision in the mediastinal pleura should be made sufficiently posterior to the phrenic nerve with its vessels in order to avoid the risk of injury to these structures when the mediastinal pleura is later sutured Care must be taken that only gentle traction is applied on any temporary encircling thread placed around the vagus nerve Dissection is best begun over the aorta, as it is easier to identify the proper cleavage plane here Some surgeons recommend that the aorta be freed in its entire circumference, both above and below the ductus, before dissection of the ductus itself is begun They advise this so as to permit quick clamping of the aorta if the ductus should inadvertently be torn This maneuver is not without its own risks an intercostal or bronchial branch of the aorta may be injured in such a dissection We only employ this technic in special situations where more than th ductal injury is anticipated. Patience on the part of the surgeon are amon portant factors in avoiding ductal in dissection.

If umbilical tape is employed to ductus, it is mandatory that the tape vaselinized so that some vaseline will as the knot is firmly tied. Otherwise, tell when a tape has been tied suffic this point is carefully observed, tying tape can be very satisfactory because (one at the aortic and the other at the p of the ductus) will give a broad area o sion. The ends of each of the tapes are tied together with a silk suture No m employed. Thorough closure of th pleura is mandatory if umbilical tape otherwise erosion of the projecting adjacent lung is a possibility We hav occur when the mediastinal pleura pleural cavity is routinely drained with which is inserted through a stab woun connected for underwater closed drai

In cases of patent ductus arteriosus pulmonary hypertension to cause po of flow through the ductus during at the cardiac cycle the ductus shou clamped with a Potts ductus clamp in

DISCUSSION—DR. TUROFF (cont.)

the heart to beat more slowly and forcefully. The vertical incision in the mediastinal pleura is made between the phrenic and vagus nerves (Plate 222B) and should be about 2 inches long. A few small mediastinal lymph nodes usually are encountered after the mediastinal pleura has been incised. The incision is best made with long, fine scissors. Scissors likewise are employed to incise the pericardial lappet (Plate 95C). Small "peanut" sponges on long artery clamps then are used to free the pericardial lappet from the ductus in a caudad direction. A search is made for the recurrent laryngeal branch of the vagus nerve, for this is the most important landmark available for determining the precise position of the ductus (Plate 95E).

From this point on, the surgeon's two most valuable instruments are a pair of fine (¼ inch wide) malleable retractors and a blunt, curved cystic duct clamp. The ductus is freed by repeatedly opening and closing the aforementioned clamp along the superior and inferior surface of the ductus. The clamp is thus worked slowly beneath the deep aspect of the ductus from above and below. As the ductus is freed progressively, the fine malleable retractors are introduced to hold the tissues above and below the ductus away from the latter structure. From time to time, counterpressure is made with the left index finger against the tip of the closed clamp as it is slowly advanced behind the ductus (Plate 95F). Sharp instruments such as a scalpel or ligature carrier never should be used in freeing the deep surface of the ductus from the underlying structures (left main bronchus, left branch of the pulmonary artery, and recurrent laryngeal nerve).

Once the ductus has been freed completely (Plate 96H), a ligature should be placed around it and the lumen of the ductus temporarily obliterated. This maneuver is valuable in determining whether or not the ductus is acting as a necessary bypass for some other congenital cardiac anomaly. If it is, the patient will become cyanotic, and, thus, permanent interruption of ductal flow will be contraindicated. Contrariwise, if the patient does not become cyanotic and the heart beat becomes slower and more forceful, ductal interruption may be performed.

The methods of ductal ligation and division illustrated in Plate 96 I, J, K, L, and M are those usually employed and are adequate.

I personally prefer the anterior approach with double ligation of the ductus using heavy braided silk and have found it to be adequate in the vast majority of cases. Should the ductus be unusually short and of large caliber, indicating ductal division as the method of choice, the anterior incision can be carried well posteriorly into the axilla to provide adequate exposure for safe ductal division.

F The ductus is freed posteriorly by blunt dissection with a Mixter type clamp This dissection is facilitated if the index finger of the left hand of the surgeon is inserted above the ductus in the sulcus between the aortic arch and the pulmonary artery In freeing the ductus posteriorly the blunt dissection is maintained toward its aortic end where the tissues are thicker and accordingly the danger of producing a tear in the ductus is lessened. This complication is most likely to occur during the posterior dissection and usually at the line of junction of the ductus and the pulmonary artery

G The Mixter type clamp is inserted from above the ductus down into the dissected space posteriorly to confirm the completeness of the dissection.

H. A clamp is inserted behind the mobilized ductus preparatory to withdrawing an encircling ligature of No 1 braided silk.

H_1 Inset to show an alternate method of placing the encircling ligature using a malleable ligature carrier with a ball point protective tip This instrument was originally designed for use in operations upon the patent ductus

I. The ductus arteriosus is occluded with two ligatures of No 1 braided silk, and Cushing silver brain clips are placed on the ends of the ligatures just distal to the knots These clips serve as a roentgenographic landmark and also prevent the knots of the ligatures from slipping. The use of umbilical tape as a ligature has been discontinued because of the inability to set the knots sufficiently tight to obtain satisfactory obliteration of the ductus.

J If preferred the mobilized ductus may be doubly clamped (Potts multitoothed clamps) and severed as indicated. This method, practiced routinely by Gross and Potts, is admittedly the best technic to assure complete and permanent obliteration of the ductus. However with the use of this method, the possibility of technical errors is increased. Accordingly double ligation in continuity is preferred as the routine method. However in selective cases particularly when the ductus is wide in diameter severance of the ductus and suture closure of the divided ends as subsequently shown, is preferred.

K. A close up and magnified view of the severed ends of the ductus to show the details of the suture closure as described by Potts.

L, M. The closure of the severed aortic end of the ductus is being completed (L) and the relation of the severed and occluded ends of the ductus to the surrounding structures is visible (M)

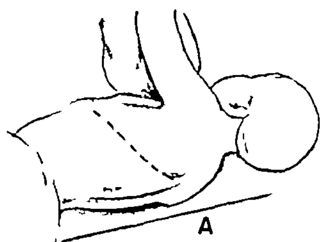
N The mediastinal pleura is loosely sutured as demonstrated. The closure of the mediastinal pleura, originally stressed by Jones, is believed an important technical step in the prevention of postoperative complications, particularly aortobronchial fistulas.

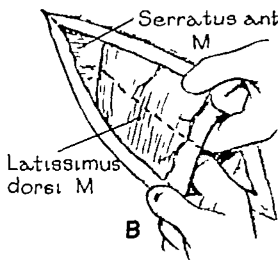
DISCUSSION—DR MAIER (cont.)

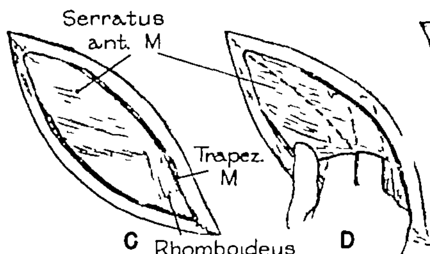
termine whether obliteration of the ductus is tolerated

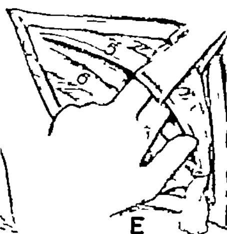
When the ductus is to be divided, it is essential that it be thoroughly dissected out so that advantage can be taken of its full length. The ductus appears longer after such dissection. The Potts multitoothed clamps are ideal for ductal division The clamps should be tested from time to time to ascertain that misuse has not impaired the proper apposition of the fine teeth The clamps must be placed sufficiently far apart to leave a good cuff of vessel projecting beyond each clamp after the ductus has been carefully transected midway between the two clamps. In order to obtain sufficient distance the clamps may have to "ride up" on the aorta or pulmonary artery An extra set of Potts multitoothed clamps is a highly desirable safety measure in case the original clamps are found to be imperfectly placed after the ductus has been divided.

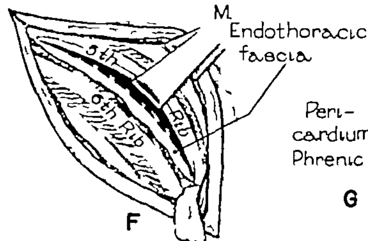
Failure to obliterate permanently a patent ductus arteriosus by operation is usually due to either infection or failure to occlude the ductus completely by encircling ligatures or tapes When recanalization occurs because a ligature cuts through, infection often plays a role, except if transfixion sutures were placed through the ductus itself We have never employed transfixion sutures, since their use seems unnecessarily hazardous to us.

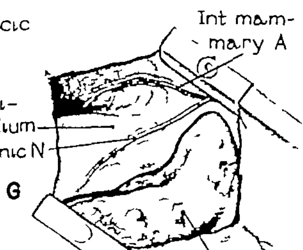

A

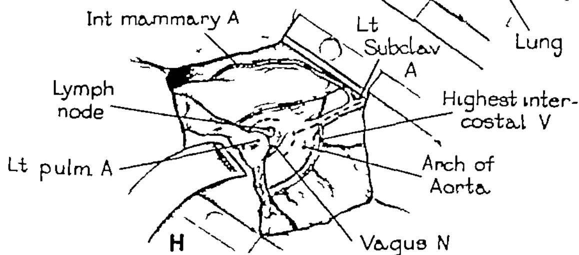

Serratus ant M
Latissimus dorsi M
B


Serratus ant. M
Trapez. M
C
Rhomboideus M
D


5
6
E


5th
6th Rib
Rib
Endothoracic fascia
F


Int mammary A
Pericardium
Phrenic N
G
Lung


Int mammary A
Lt Subclav A
Lymph node
Highest intercostal V
Lt pulm A
Arch of Aorta
H
Vagus N

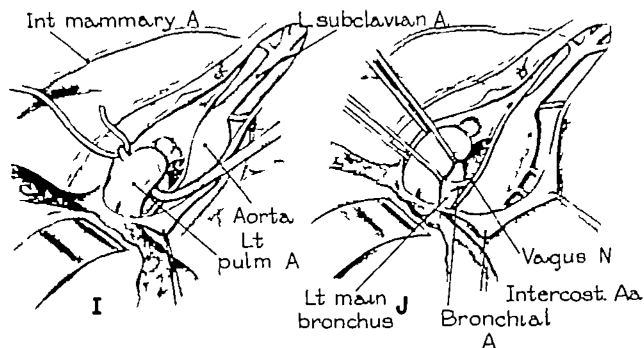
DISCUSSION—DR. ARTHUR S W TOUROFF Two surgical approaches are commonly employed in cases of patent ductus arteriosus. The first is anteriorly and extends from the left lateral border of the sternum to the anterior portion of the axilla. The second approach is lateroposteriorly

If an anterior incision is used, its site is best determined by the level of the under surface of the aortic arch as seen in an x ray film of the chest. With the patient in the supine position, the incision usually is made along the third intercostal space. After the left hemithorax is entered, the third costal cartilage is divided close to the sternum. If additional exposure is required, the second costal cartilage may be divided. In adult females, the incision is made beneath the breast and the latter mobilized upward until the region of the third intercostal space is exposed. The postoperative cosmetic result is excellent.

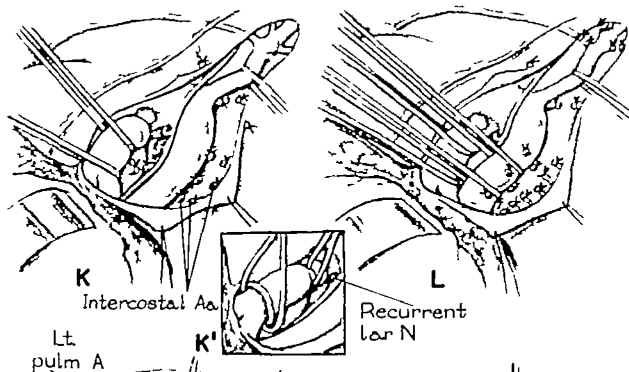
If the lateroposterior approach is employed, the patient is placed in the right lateral recumbent position. A sweeping subscapular incision is made from the level of the third rib posteriorly and carried downward and around the angle of the scapula (Plate 95A) The pleural cavity is entered through the fourth intercostal space after dividing the fourth rib close to its posterior attachment.

Each incision has certain advantages and disadvantages with which the well-trained surgeon should be familiar The anterior approach is shorter more direct, divides relatively little muscle tissue and can be performed much more rapidly and with much less bleeding than the lateroposterior approach. Inasmuch as the patient does not lie on the incision following operation, there is apt to be considerably less pain than when the lateroposterior approach is employed. However the surgical exposure of the ductus is not as good. The lateroposterior approach requires a long incision, and the scapula must be freely mobilized in order to expose the fourth intercostal space which lies beneath it. In order to accomplish this, a good deal of musculature must be divided. This requires considerably more time, and numerous bleeding vessels must be clamped and ligated. Similarly the surgical closure is time-consuming. Since the patient frequently lies on his back, the incision is apt to be much more painful postoperatively than when an anterior incision is employed. However the lateroposterior incision provides better exposure of the ductus, especially of its deep or posteromesial aspect. This area and the left branch of the pulmonary artery are the two structures which are most liable to be injured during the process of freeing the ductus from the surrounding structures.

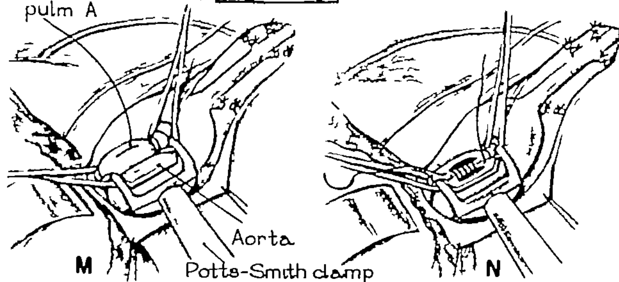
The site of the ductus is best determined at operation by palpating the area in the concavity of the distal portion of the aortic arch. There, a thrill will be felt which is maximal directly over the ductus. Once discovered, firm pressure on the ductus with the index finger will cause the thrill to disappear and



Int mammary A
L subclavian A
Aorta
Lt
pulm A
I
Vagus N
Intercost. Aa
Lt main
bronchus
J
Bronchial
A



K
L
Intercostal Aa
Recurrent
lar N
K'



Lt.
pulm A
Aorta
M
Potts-Smith clamp
N

A. The patient is placed in the direct right lateral prone position and a pillow support is inserted between the extended arms The lateroposterior thoracic incision employed is seen in dotted outline.

B. The latissimus dorsi muscle is first mobilized posteriorly and then compressed between the index fingers and thumbs of the surgeon and the first assistant respectively as it is transected (dotted lines) The digital compression is released intermittently for the identification of the severed vessels and the application of clamps for hemostasis. The clamps are subsequently replaced by suture ligatures of 000 silk. This particular technic for the transection of the muscles of the thoracic cage minimizes both blood loss and tissue trauma

C. The severance of the latissimus dorsi and trapezius muscles is completed, and the underlying serratus anterior and rhomboideus major muscles are visible.

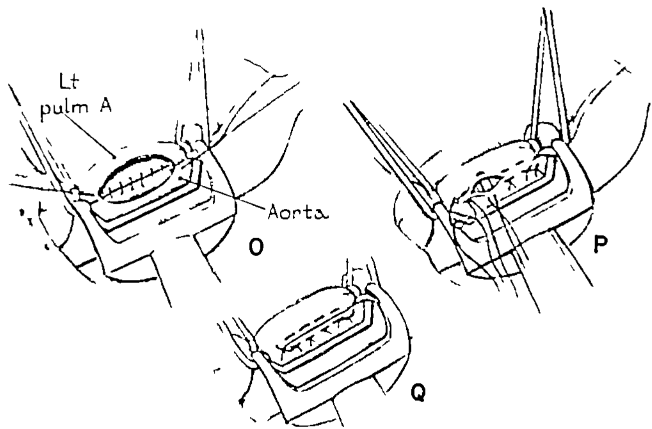
D Prior to the transection (dotted line) of the serratus anterior (serratus magnus) muscle the fingers of the right hand of the surgeon are inserted beneath the scapula, and the intercostal interspace to be entered (fifth) is identified. This is facilitated by counting downward from the highest rib palpable, the second rib

E. The lower half of the periosteum of the fifth rib is removed, and by digital dissection the endothoracic fascia and the pleura are separated from the third fourth, and fifth ribs and the intervening musculature This particular technic, credited to Sir R. C Brock of England is used almost as a routine in the performance of a thoracotomy It permits an adequate exposure of the intrapleural surgical field without the necessity of resecting a portion of a rib or severing the related intercostal muscle bundle A portion of a gauze sponge located beneath the erector spinae muscle group is visible.

F The fifth rib is retracted upward the site of the incision in the subjacent endothoracic fascia and parietal pleura is indicated by the dotted line

G. The left pleural cavity is entered and the rib margins covered by protective moist toweling, are separated by a self retaining retractor (Tuffier) to expose the structures as depicted.

H. The deflated upper lobe of the left lung is covered by a moist gauze protective pad and retracted downward and posteriorly The incision in the mediastinal pleura, which partially encircles the anterior and posterior aspects of the hilum (dotted line), and the related intrapleural structures are demonstrable.



R^1

R^2

R^3

R^4

I. In opening the mediastinal pleura which is now completed it is usually necessary to ligate doubly and sever the highest intercostal vein. The left pulmonary artery mobilized completely about its circumference, is being encircled with a cotton (umbilical) tape The relation of the artery to the surrounding structures is visible.

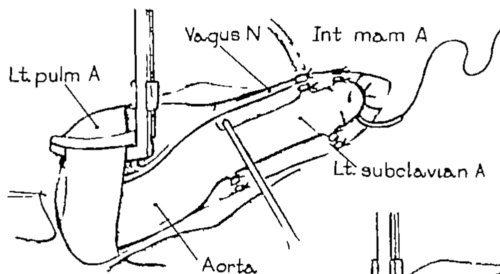
J The pulmonary artery encircled by two cotton tapes is displaced medially to expose portions of both the left main stem bronchus and one of the bronchial arteries. The vagus nerve and its recurrent laryngeal branch, which arches upward beneath the lower border of the ligamentum arteriosum at its aortic end and then passes behind the arch of the aorta (dotted line) into the neck, are also visible

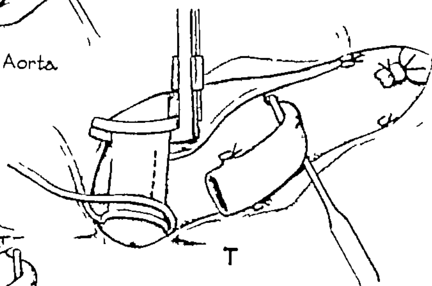
K, L. One of the bronchial arteries, the upper three sets of intercostal arteries, and the branches of the subclavian artery within the thorax are doubly ligated and severed The ligated ends of a small arterial branch from the base of the subclavian artery may be seen In this patient, a four and-one-half year-old boy an end to-side anastomosis between the left subclavian artery and the pulmonary artery (Blalock) was originally planned. However following exploration, the subclavian artery was believed too narrow in diameter to effect an adequate shunt, and, accordingly a side-to-side aortopulmonic anastomosis (Potts) was the operation of choice

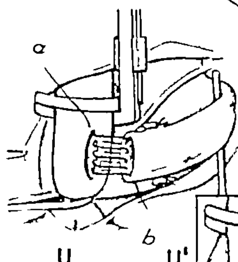
K[1] Inset showing the left pulmonary artery occluded proximally by a double encircling cotton tape ligature A similar ligature, loosely encircling the artery distally may be seen. This ligature will be subsequently tightened by traction to occlude completely the intervening segment of the left pulmonary artery

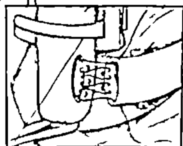
M. The mobilized segment of the proximal portion of the descending aorta is partially occluded in a Potts–Smith clamp and approximated to the occluded segment of the left pulmonary artery To maintain approximation, one strand of each of the occluding tape ligatures on the pulmonary artery is passed beneath the metal bar on either end of the jaw of the clamp and, by traction on the tapes, both the arterial occlusion and the approximation of the vessels are adequately maintained. If preferred, the ligature strands may be tied to the jaws of the clamp The sites of the incisions in the occluded segments of the aorta and the pulmonary artery are shown in dotted outline. The length of each of the incisions measured by a caliper is 6 mm. It is important not to make the anastomotic stoma too large and yet it must be adequate in size to be effective.

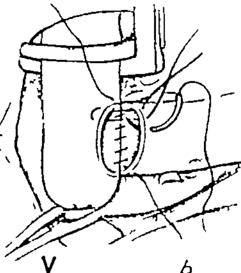
N The openings into the lumen of the aorta and the pulmonary artery are made, and the insertion of the posterior suture layer is completed. A continuous over and over suture of 00000 arterial silk, which starts from the "outside in" on the aorta and terminates from the "inside out" on the pulmonary artery is used

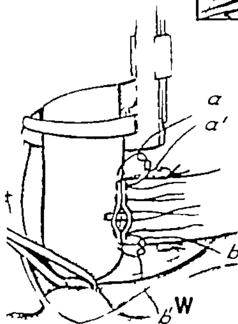

Vagus N
Int mam A
Lt. pulm A
Lt. subclavian A
Aorta
S

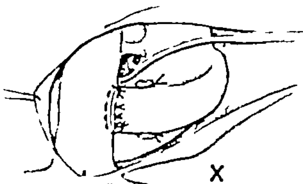

T


a
b
U


U'


a
V
b

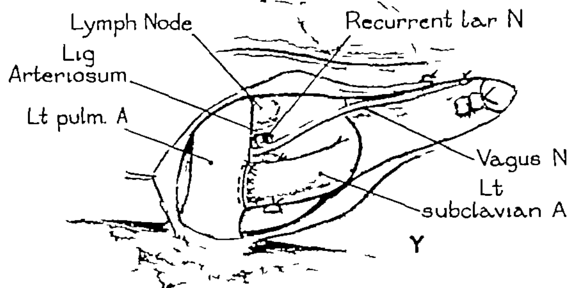

a
a'
b
b'
W

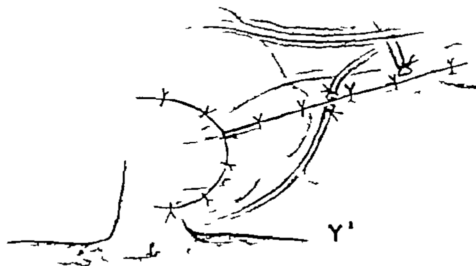

X

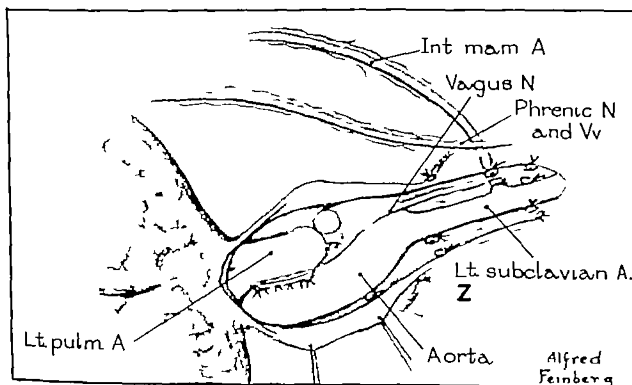
O Close up view of the completed posterior layer of the anastomosis The presence of the line of sutures within the lumen of the blood vessels though theoretically objec tionable, has not produced any untoward symptoms.

P Q Close up views of the anterior layer of the anastomosis during (P) and following its completion (Q) A series of interrupted everting mattress sutures of silk (00000) is used for the closure of the anterior layer If desired, either a continuous over and over or everting type of suture may be employed At either end of the anastomosis one of the strands of the adjacent mattress suture is tied to the free end of the suture forming the posterior layer

R¹ R² R³ R⁴ These close-up views illustrate an actual occurrence during the perform ance of an aortopulmonic anastomosis (Potts) Accordingly it is believed that it may be of technical surgical interest. Follow ing the completion of the posterior layer of the anastomosis, it was observed that the central portion of the anterior lip of the in-cised aorta had slipped beneath the upper blade of the Potts-Smith clamp (R) This technical difficulty was dealt with satisfac torily by first occluding the aorta com pletely both proximally and distally to the site of the anastomosis with angulated Potts ductus clamps (R) The Potts-Smith clamp was then quickly removed, and a series of simple interrupted sutures of silk (00000) were inserted (R) and drawn taut (R). The Potts–Smith clamp was then reapplied, and the angulated ductus clamps occluding the aorta were removed (R) Subsequently the anterior layer of interrupted sutures was tied to complete the anastomosis (R) In this patient the total time of complete aor tic occlusion was six minutes. The conva-lescence of the patient was uneventful.


Lymph Node
Recurrent lar N
Lig
Arteriosum
Lt pulm. A
Vagus N
Lt
subclavian A
Y


Y'


Int mam A
Vagus N
Phrenic N
and Vv
Lt. subclavian A.
Z
Lt. pulm. A
Aorta
Alfred
Feinberg

If both the diameter and the length of the subclavian artery are adequate in size, it may be used for an anastomosis to the pulmonary artery (Blalock technic) In fact, if given a choice, this method is preferred to the performance of a side-to-side anastomosis between the pulmonary artery and the aorta (Potts technic). Although the use of the right subclavian artery has been advocated by Blalock because of the unobstructed arch it forms with the innominate, the use of the left subclavian artery is preferred. Technically the left subclavian artery is easier to mobilize and the objection to the angulation that occurs at its origin from the aorta is believed more theoretic than real.

S The proximal portion of the left pulmonary artery is occluded with a Blalock clamp and a Potts angulated ductus clamp is applied across the base of the left subclavian artery the branches of which have been previously ligated and severed. The subclavian artery is occluded distally by a ligature of silk (0) immediately proximal to which a transfixion suture ligature is being inserted. The site of transection of the subclavian artery is indicated by the dotted line

T The proximal transected end of the left subclavian artery is turned downward toward the pulmonary artery which is doubly encircled distally by a cotton tape that will be used subsequently to occlude completely the lumen of the pulmonary artery The site for the incision into the lumen of the pulmonary artery is shown by the dotted line

U U[1] The insertion of the continuous over and over suture (00000 silk) posteriorly is completed but it is not drawn taut This suture starts from the "outside in" at the proximal end of the opening in the pulmonary artery and terminates from the "inside out" at the lateral angle of the transected proximal end of the left subclavian artery If preferred, a continuous everting mattress suture may be used (U). This suture starts from the "outside in" at the medial angle of the proximal transected end of the subclavian artery and finishes from the "outside in" at its lateral angle.

V The posterior suture is drawn taut to complete the posterior layer of the anastomosis, and the insertion of the everting interrupted mattress sutures anteriorly is begun.

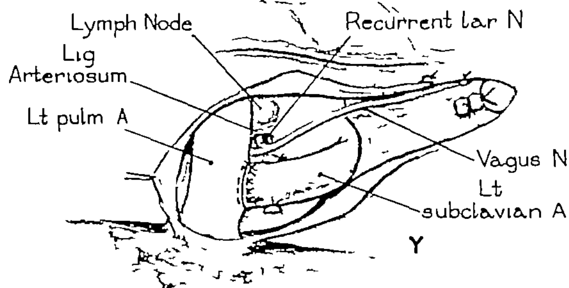
W The insertion of the interrupted mattress sutures which form the anterior layer of the anastomosis is completed, and all but one are tied. At either angle of the anastomosis, one of the strands of the adjacent mattress suture anteriorly is tied to either free end of the continuous suture posteriorly (a, a and b b)

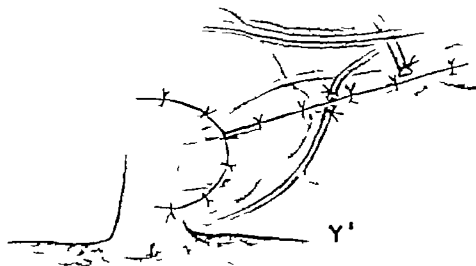
X. The completed end to-side anastomosis of the left subclavian artery to the side of the *left pulmonary artery is depicted. Although* the angulation of the left subclavian artery at its site of origin from the aorta is theoretically objectionable the clinical results obtained with its use have proved satisfactory

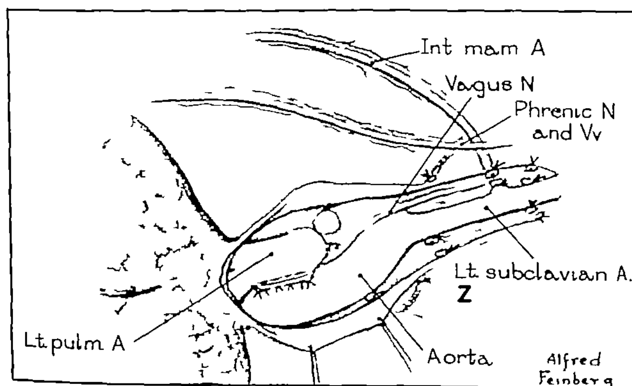
DISCUSSION—DR ALFRED BLALOCK *Anesthesia* The patient should not be deeply anesthetized. Control of respiration greatly facilitates the operation The use of hypothermia is rarely indicated

Incision If a subclavian-pulmonary anastomosis is planned, an anterolateral incision is used. The pleural cavity is entered through the second or third interspace the second is preferred. If an aortic-pulmonary anastomosis is planned, a posterolateral incision is used. The anterior incision has the advantage of interfering less with respiratory function.

Choice of systemic artery In approximately 25 per cent of patients with the tetralogy of Fallot, there is a right aortic arch. In such patients the innominate is on the left instead of the right. Since we prefer when possible to use the subclavian that arises from the innominate, the incision generally is made on the right when there is a left arch and on the left when there is a right arch. At times we use the subclavian that arises directly from the aorta but much


Lymph Node
Recurrent Lar N
Lig
Arteriosum
Lt pulm A
Vagus N
Lt
subclavian A
Y


Y'


Int mam A
Vagus N
Phrenic N
and Vv
Lt. subclavian A.
Z
Lt. pulm A
Aorta
Alfred
Feinberg

Y The relation of the completed end to-side anastomosis between the left subclavian artery and the left pulmonary artery (Blalock operation) to the surrounding structures in the operative field is visible

Y[1] The same field as in Y after closure of the mediastinal pleura.

Z. The relation of the completed side to-side anastomosis between the aorta and the left pulmonary artery (Potts operation) to the adjacent structures is shown. The previously isolated left subclavian artery which at operation was considered too narrow in diameter to use, may be seen. It was this finding which indicated the performance of the Potts rather than the Blalock procedure.

DISCUSSION—DR. BLALOCK (cont)

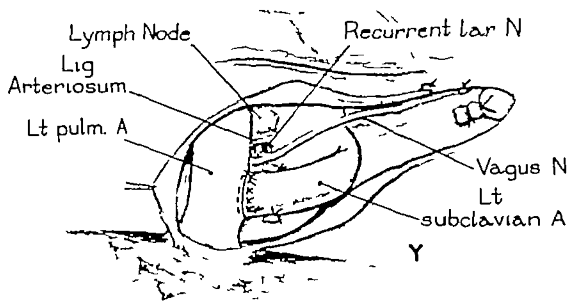
prefer that arising from the innominate. Sharp angulation is thereby avoided

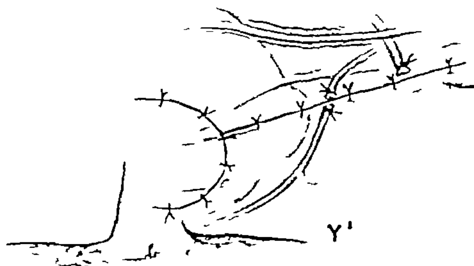
There are some exceptions to the following general statements In children between the ages of 2 years and 12 years, an end-to-side anastomosis is performed between the subclavian branch of the innominate artery and the pulmonary artery In infants the Potts aortic–pulmonary anastomosis is usually used because the subclavian is too small. In patients over the age of 12 years, the subclavian branch of the innominate may be too short, and we usually use the Potts type or the subclavian branch of the aorta

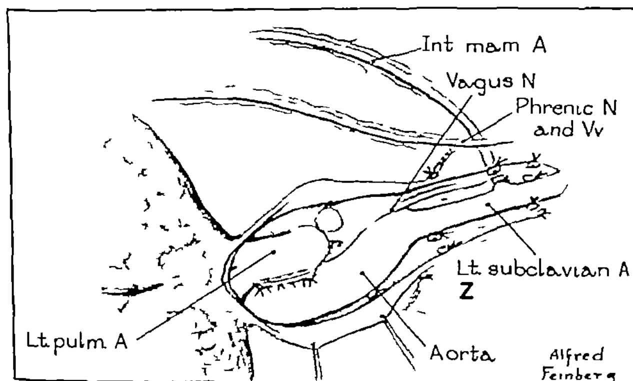
Size of anastomosis. When using the subclavian artery one need have little fear of causing heart failure. When using the aortic–pulmonary anastomosis one should not make the opening more than 5 or 6 mm in diameter or heart failure is apt to follow We have the impression that a subclavian pulmonary anastomosis of a given size is less apt to cause heart failure than an aortic pulmonary union of the same size

Bilateral operation In approximately 110 of our 1500 patients with Fallot s tetralogy or some variation of it, a second operation on the opposite side has been performed. The indications have been closure of the first anastomosis or inadequacy of the shunt associated with growth of the patient. If the first operation consisted of a shunt between the right subclavian and pulmonary arteries, the second operation consists of an anastomosis between either the aorta or the left subclavian and the left pulmonary artery If the patient has a right aortic arch and the first operation consisted of a shunt between the left subclavian and left pulmonary arteries, in performing a second operation on the right, one may have to use a graft in connecting the aorta with the right pulmonary artery

Open heart surgery When the operative mortality is reduced further and when the results of a longer follow-up period become known, it is likely that the direct open attack will largely replace the shunt procedures except in cases of tricuspid atresia, pulmonary atresia, and similar situations. The likelihood that this will occur is a point in favor of subclavian-pulmonary anastomosis rather than aortic–pulmonary anastomosis because the former can be closed more readily if it is advisable to do so in the future.


Lymph Node
Recurrent Lar N
Lig Arteriosum
Lt pulm. A
Vagus N
Lt subclavian A
Y


Y'


Int mam A
Vagus N
Phrenic N and Vv
Lt. subclavian A
Z
Lt. pulm. A
Aorta
Alfred Feinberg

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DISCUSSION—DR. BLALOCK (cont.)

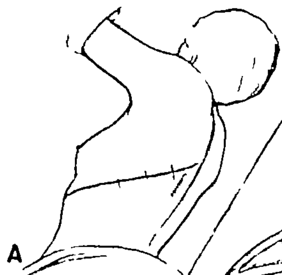
prefer that arising from the innominate. Sharp angulation is thereby avoided.

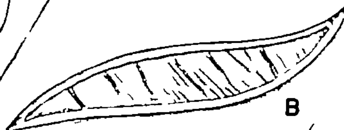
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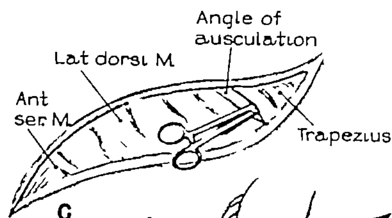
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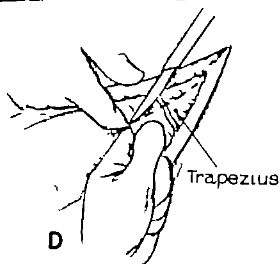
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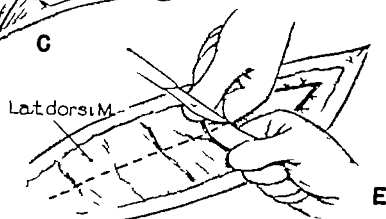
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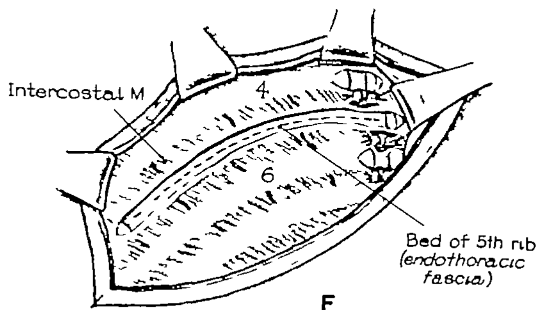

A


B


Angle of
auscultation
Lat dorsi M
Ant
ser. M
Trapezius
C


Trapezius
D


Lat dorsi M
E


Intercostal M
4
6
Bed of 5th rib
(endothoracic
fascia)
F

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DISCUSSION—DR BLALOCK (cont)

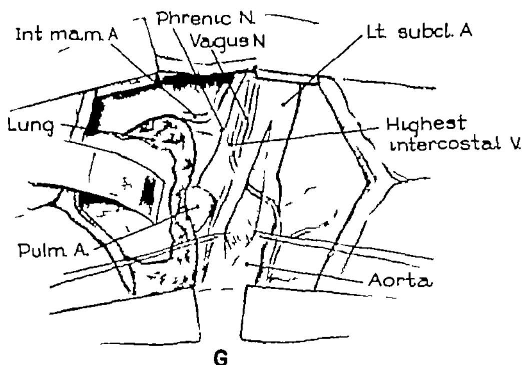
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Vagus N

Coarcted segment

Pleura

H

I

Recurrent laryngeal N

Ductus arteriosus

Intercostal arteries

J

Bronchial arteries

Paired intercostal arteries

K

COARCTATION OF THE AORTA

A. The patient is placed in the direct right lateral prone position, and the site of the left thoracotomy incision is outlined and cross hatched to facilitate later closure

B C. The incision is deepened through the subcutaneous fat and fascia to expose the underlying musculature and the accompanying large collateral blood vessels.

D E. The trapezius and latissimus dorsi muscles respectively are compressed between the thumbs and index fingers of the surgeon and first assistant, and the muscle fibers are severed with a scalpel The muscles are incised for only short lengths at a time and, as the digital compression is released, bleeding points are identified and clamped. Hemostasis is then secured with suture ligatures of silk (000) This method for severance of the muscles prevents excessive blood loss and its use is believed mandatory in all thoracotomies performed for coarctation of the aorta.

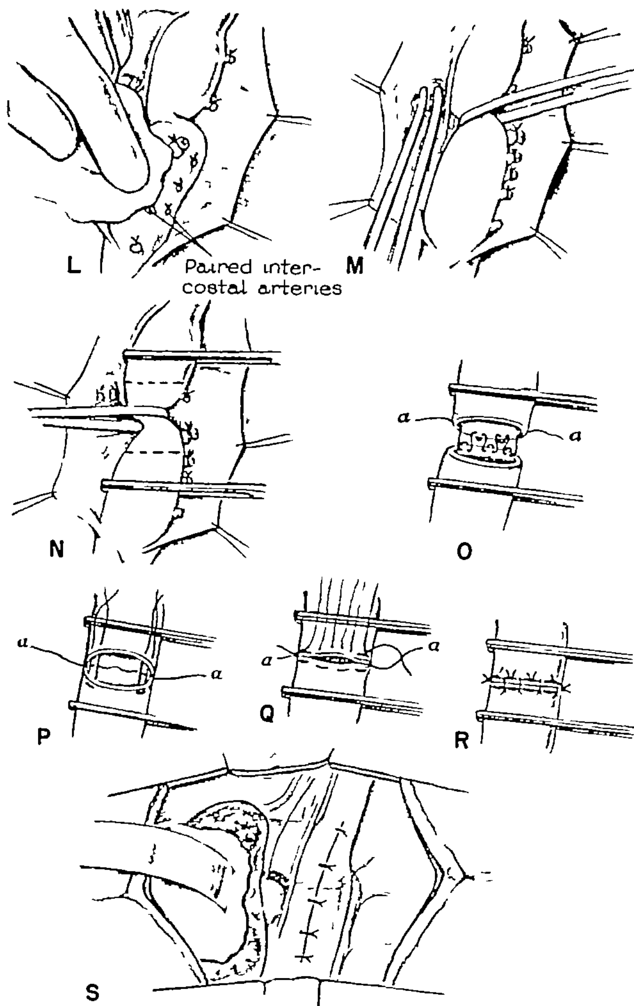
F A subperiosteal resection of a long segment of the fifth rib and short segments of the fourth and sixth ribs is performed. The intervening intercostal bundles are clamped, severed, and ligated with suture ligatures of 00 silk. The incision in the bed of the resected fifth rib is depicted by the dotted line In some instances resection of a long segment of the fourth rib and short posterior segments of the third and fifth ribs may prove more desirable

DISCUSSION—DR RALPH A. DETERLING JR. In general, I have favored a curved incision for high thoracotomies For repair of coarctation my incision begins horizontally passing about 1 cm below the tip of the scapula and curving cephalad between the scapula and the spinous processes of the thoracic vertebrae Because of the very large subcutaneous collateral arteries, I develop the skin incision in lengths of about 10 cm., securing bleeding vessels before continuing. In this way blood loss may be minimal

Regarding the division of the muscles of the chest wall in these patients, I personally prefer not to introduce instruments or fingers blindly beneath the muscles (Plate 102C, D E) I have seen very troublesome bleeding occur because of injury to the dilated thin-walled arteries entering the muscles from the chest wall I prefer to cut the muscle with a gentle sawing action, deepening the incision slightly with each stroke. The arteries to the muscles may be readily observed before being cut and can be secured with clamps without blood loss. The slight extra expenditure of time is compensated for by the loss of only minimum quantities of blood.

I have generally resected only the fourth rib subperiosteally In contrast to the method of standard thoracotomy I do not separate the erector spinae muscle group from the posterior segment of the rib until the rib is completely freed from periosteum elsewhere If the large perforating posterior branch of the intercostal artery is then opened inadvertently the rib can be removed at once for better exposure and the control of hemorrhage. I have been satisfied with the use of ligatures of 0000 a d 000 silk

I have found two Tuffier retractors (Plate


L
M
Paired inter-costal arteries
N
a
a
O
a
a
P
a
a
Q
R
S

G The wound margins and rib cage are separated with two self retaining (Tuffier) retractors, and the operative field is exposed. An incision is made through the pleural covering of the aorta, and its cut margins are retracted by guy sutures of silk (0000) to show more clearly the underlying highest intercostal vein and the surrounding fibroareolar tissue layer

H I *The incision in the pleura is extended* and the highest intercostal vein is doubly ligated and severed The dissection of the surrounding fibroareolar tissue is completed to demonstrate the coarcted segment of the aorta and its related structures The poststenotic dilatation of the aorta and the enlarged intercostal arteries are visible. In this particular patient there were two branches from the segment of the aorta proximal to the site of the coarctation.

J Inset showing the ligated stumps of two of the severed intercostal arteries and the insertion of a transfixion suture of silk (000) in the uppermost and largest of the three intercostal arteries. The site of severance of this artery is indicated by the dotted line. Clamps are not used because of the frequent friability of the vessels. Every precaution should be taken to secure adequate hemostasis and prevent the excessive bleeding that may accompany the slipping of a ligature. If hemorrhage should occur from a severed intercostal artery the best method for hemostasis is for the surgeon to insert the index finger of the left hand behind the aorta, the circumference of which is always mobilized prior to ligation and severance of the intercostal vessels, and compress the aorta between the thumb and the index finger about the site of the hemorrhage. The operative field is then cleared of blood by irrigation with saline solution and suction siphonage. The bleeding site is visualized and hemostasis is obtained with suture ligatures of arterial silk (00000) swedged on a minimum trauma needle. Preservation of the collateral pathways through the enlarged intercostal arteries is frequently stressed, but the necessity for this is questioned if resection of the coarcted segment and restoration of aortic continuity either by direct anastomosis or the insertion of a graft, is feasible.

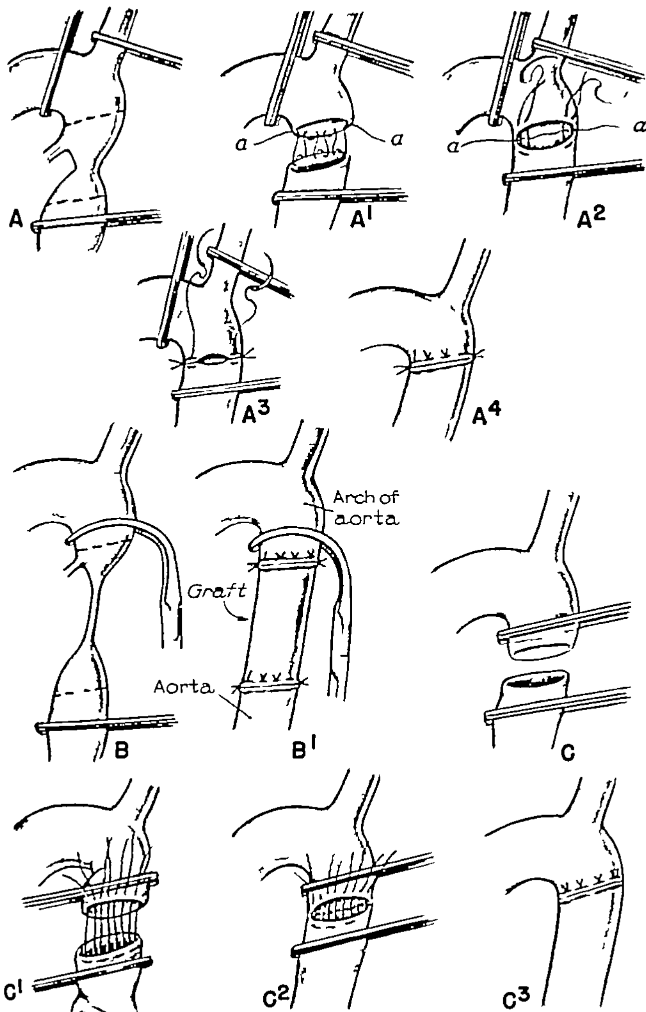
K. The uppermost paired intercostal arteries and the bronchial arteries are ligated and divided, and the aorta, the coarcted segment, and the subclavian artery respectively are encircled with umbilical tapes. As mentioned previously this is done prior to ligation and division of the intercostal arteries to facilitate the control of bleeding should hemorrhage occur The relation of the recurrent laryngeal branch of the vagus nerve to the inferior surface of the ductus arteriosus (patent in this patient) is demonstrated. The operative field is now in readiness for division of the ductus arteriosus and resection of the coarcted segment of the aorta.

DISCUSSION—DR DETERLING (cont.)

103G) difficult to keep in place, even with double thickness pads over the rib edges. Not infrequently one is opened wider than the other or else they angulate during the operative procedure. A single Burford retractor with a large blade above and small blade below has been simpler to keep in proper position in the midportion of the wound.

The author has done well to point out the variation observed in the minor aortic branches (Plate 230H I) On occasion a branch passes posteriorly from the dilated subclavian artery at its origin and can be easily damaged during the mobilization of the subclavian artery

I agree heartily with the author's admonition against the use of clamps on the intercostal arteries (Plate 103J K) These friable arteries easily pull out of the wall of the aorta with merely the weight of a hemostat. Prior to the division of the first set of intercostal arteries and bronchial arteries (Plate 103J K, Plate 104L) I have preferred to perform first the step subsequently described by the author (Plate 104M)


a
a
A
A1
a
a
A2
A3
A4
Arch of aorta
Graft
Aorta
B
B1
C
C1
C2
C3

L. The thoracic aorta below the coarctation is rotated on its longitudinal axis, and the ligated stumps of the paired intercostal arteries are demonstrated

M. The patent ductus arteriosus is isolated *and doubly clamped prior to its division.* The recurrent laryngeal nerve curves upward and passes inferior and posterior to the aortic end of the ductus Its preliminary exposure provides an important landmark for the identification of the ductus Furthermore, in the application of clamps and ligatures to the ductus one must be careful to avoid injury to this nerve

N The coarcted segment is completely mobilized, and Potts multitoothed straight clamps are applied across the aorta above and below the area of coarctation. The extent of the resection is indicated by the dotted lines In the resection of the area of coarctation it is most important to remove a sufficiently long segment, both proximally and distally to assure an adequate size of the aortic lumen upon completion of the anastomosis. However if after the resection a direct anastomosis cannot be performed without undue tension on the suture line, a graft or prosthetic replacement should be employed. The use of a graft should always *be considered in the older adults in whom* extensive arteriosclerosis and concomitant friability of the aorta may be present

O The posterior suture layer of the anastomosis is inserted. This is a continuous eversion type of suture (silk, 00000) with intima to intima approximation The suture is commenced from the "outside in" on the proximal segment of the aorta and terminates from the "inside out" also on the proximal segment of the aorta. Between its commencement and termination, the suture proceeds from the "inside out" to the "outside in" *relative to the lumen of the aorta.* Accordingly the loops formed by the suture are always on the outside of the lumen.

P The posterior suture a–a, is drawn taut, and the intimal surfaces of the aortic segments are brought into close approximation. None of the silk suture is exposed within the lumen. The anterior layer of the anastomosis is commenced by the insertion of interrupted everting mattress sutures of silk (00000) at either angle of the anastomosis.

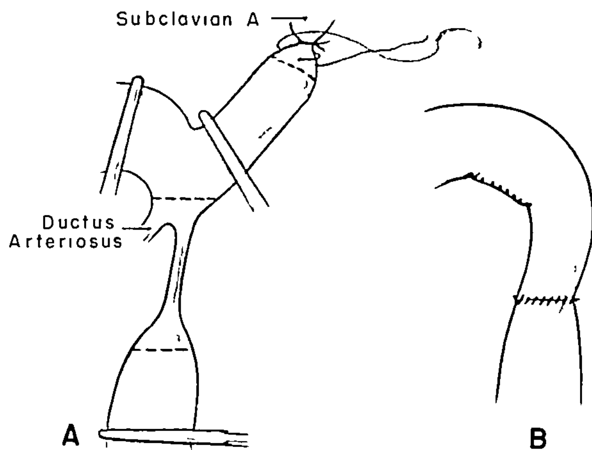
Q The remaining interrupted everting mattress sutures are inserted anteriorly but not tied The mattress sutures at either end are tied first, and one of the long ends of each of these sutures is in turn tied to either end, a–a, of the continuous everting suture of silk used for the posterior layer

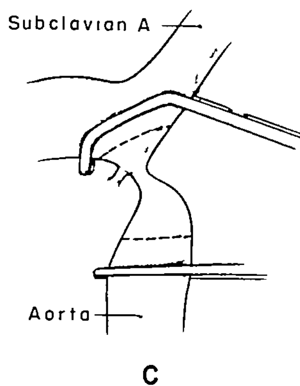
R. The intervening everting mattress sutures are tied to complete the anastomosis. Simple interrupted sutures are inserted between *the mattress sutures to reinforce the closure.*

S. The operative field following completion of the operation is depicted The site of the aortic anastomosis may be seen in dotted outline beneath the line of closure of the incision in the pleura overlying the aorta.

DISCUSSION—DR. OTTERLING (cont.)

That is, after mobilizing the subclavian artery and securing it with a double loop of narrow braided cotton tape, I pass a similar loop about the arch of the aorta proximal to the ductus arteriosus for hemostatic control I next develop the plane behind the aortic arch and region of the coarctation, and about the ligamentum arteriosum The ductus arteriosus has been patent in only 15 per cent of my cases I divide the ligamentum or ductus before mobilizing the dilated, friable aortic branches distal to this area because, if serious bleeding occurs while securing these branches, control can be effected simply by cross-clamping the mobilized aorta with two Potts coarctation clamps and dividing it With the distal end elevated gently and rolled on itself slightly the bleeding site can be easily and safely repaired with 00000 braided silk swedged on a taper point needle. The blind introduction of instruments or fingers beneath the aorta during its mobilization can lead to very serious and at times fatal hemorrhage In dividing the ligamentum arteriosum (Plate 104L, M N), I generally pass lengths of 00 silk about it, tying them at the aortic and pulmonary artery ends respectively before dividing it If there is a patent ductus arteriosus, I place Potts ductus clamps on the aortic and pulmonary artery ends of the ductus, and after dividing it with a knife, oversew the ends with a continuous suture of 00000 braided silk


Subclavian A
Ductus
Arteriosus
A
B


Subclavian A
Aorta
C

This plate depicts alternate methods for the resection of a coarcted segment of the aorta and the restoration of aortic continuity

A A^1 A^2 A^3 A^4 These illustrations demonstrate a high-lying coarctation in which mobilization of the aortic arch and cross-clamping of the arch and the left subclavian artery are required preliminary to resection and direct anastomosis

B, B^1 In the presence of a long coarcted segment of the aorta, a resection and primary anastomosis is impossible Accordingly a graft is required to restore aortic continuity This method is frequently employed in the older adults in whom the arteriosclerotic changes present may preclude a direct anastomosis It is also preferred to the use of the proximal end of the severed left subclavian artery

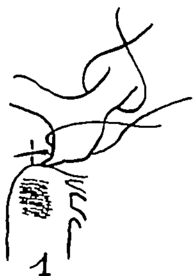
C C^1, C^2 C^3 This series of drawings depicts the technic originally described by Gross and Hufnagel for direct aortic anastomosis following the resection of the coarcted segment. The cut ends of the aorta are rotated *on their longitudinal axes, and a series of* interrupted everting mattress sutures of silk (00000) are inserted posteriorly (C^1) The aorta is then derotated, and the anterior layer of interrupted everting mattress sutures of silk (00000) is inserted (C^2) to complete the anastomosis (C^3)

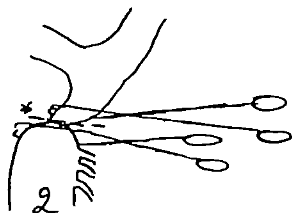
Discussion—Dr. Deterling (cont)

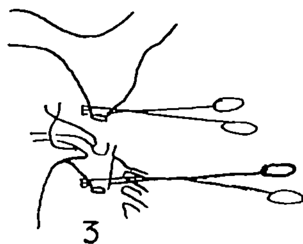
When there is a moderate disproportion of the opposed aortic ends (because of hypoplasia of the proximal segment or poststenotic dilation of the distal segment), the use of everting mattress sutures reinforced with interrupted sutures is a very secure anastomosis (Plate 104O P Q R) However in most adult cases, I employ a simple continuous suture of 00000 braided silk In infants I have used interrupted mattress sutures of 0000 chromic catgut with maximal growth as the goal As an alternate method for infants, a simple continuous suture may be used for the posterior row with interrupted sutures anteriorly (Johnson and Kirby) If even after dividing additional intercostal arteries, there is tension on the aorta while approximating the ends, I have placed the posterior continuous suture from within the aorta This obviates the need for rotating the vessel and risking additional damage from the use of clamps

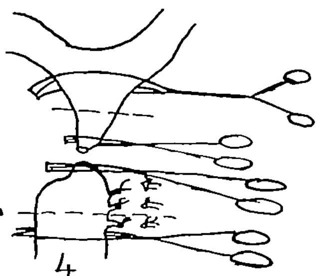
Instead of two straight clamps (Plate 105A, A^1 A^2 A^3 A^4) a Potts-Beck clamp may be used as shown in Plate 106C Circulation may thus be maintained from the aorta into the left subclavian artery and its collateral branches. In rare instances the coarctation may lie between the left common carotid artery and subclavian artery In such instances the use of multiple straight clamps may be necessary

I agree that a graft (Plate 105B, B^1) is indicated when a long stenotic segment is found Since this cannot always be predicted, the surgeon should have available a graft for immediate use in all cases of coarctation in adults. In infants and children an effort should be made to avoid the use of a graft which *would not grow at a pace equal to that of* the host vessel. By dividing additional intercostal arteries, enough length may be gained in most, if not in all, *of the cases*


1


2


3

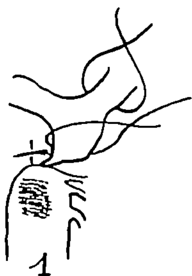

4

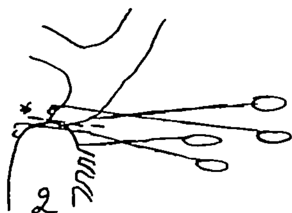
A B. In those instances in which the length of the coarcted segment precludes a direct anastomosis (A) and in lieu of a homologous aortic graft replacement or cloth prosthesis, the proximal end of the severed subclavian artery may be anastomosed to the distal severed end of the aorta (B) as originally suggested and practiced by Clagett.

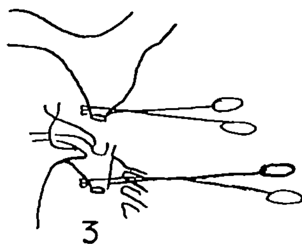
C. In the presence of a high lying coarctation of the aorta, the proximal or uppermost clamp one of the Beck–Potts type may be applied tangentially to occlude only partially the lumen of the aortic arch and the left subclavian artery

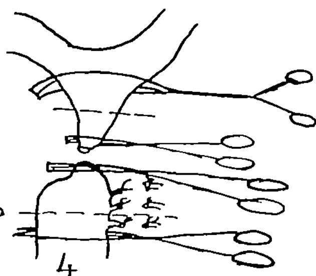
DISCUSSION—DR. DETERLING (cont)

Although I assisted Clagett in his performance of the first subclavioaortic anastomosis in a patient *with coarctation (August 6, 1946) and subsequently* performed the same operation myself in patients with long stenotic segments at the time when grafts were not available, the final hemodynamic results have not generally been so good as those observed with end-to-end aortic anastomosis or with the use of an aortic homograft. However I could conceive of this *operation still serving a purpose in a young* patient with a long stenotic segment (possibly as an interim procedure) or if graft material was unobtainable (Plate 106A, B) Usually the subclavian artery has a greater diameter than that depicted by the artist.


1


2


3


4

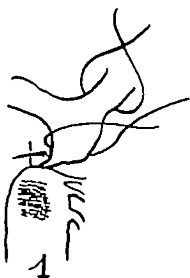
DISCUSSION—DR. CHARLES DUBOST In general, the technic I use is similar to the one illustrated. I use the same position but resect only the fifth rib without the additional resection of the fourth and sixth ribs. Similarly the site of the coarctation is exposed as depicted. I make all efforts to preserve the maximum number of intercostal arteries. If necessary the use of serrefine (bull-dog) clamps for temporary hemostasis is practiced When ligation of the intercostal arteries is deemed necessary usually there are no difficulties with the left intercostals. However on the contrary ligation of the right intercostals may prove difficult and annoying. Accordingly for the ligation of the right intercostal arteries, I sever the aorta between two clamps placed at each side of the coarcted segment, the distal segment of the aorta is turned down and the ligation of the right intercostal vessels can be done easily and without danger

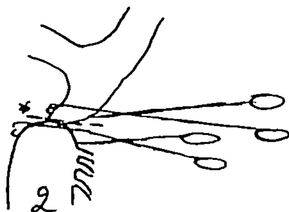
In the performance of the anastomosis I use solely interrupted sutures, as I believe this technic is easier and safer

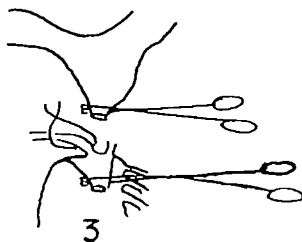
In those patients with high lying coarctations I prefer to perform the operation under moderate surface hypothermia (31 to 32 C., 87.8 to 89 6 F) This is done to avoid the risk pursuant to the clamping of the horizontal aorta and the subclavian artery

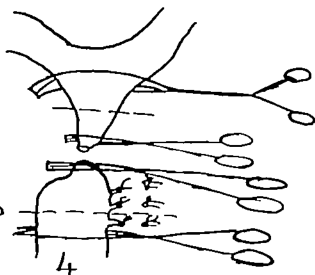
When the coarctation is of a length that precludes resection and primary anastomosis, and in those patients with associated aneurysms, I prefer the use of a knitted dacron graft for restoration of aortic continuity

My own series of patients in which a resection has been performed for coarctation of the aorta now numbers 450 Of this number the grafts represent approximately 8 per cent.


1


2


3


4

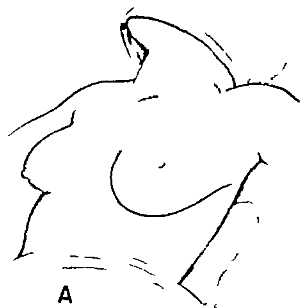
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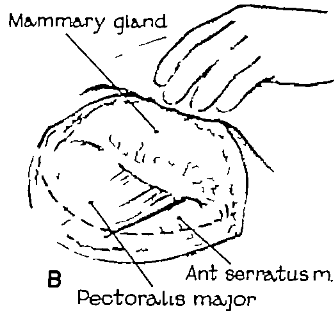
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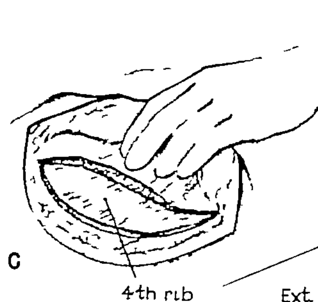
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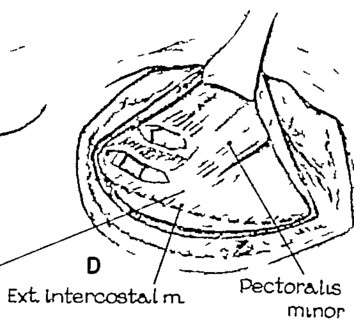
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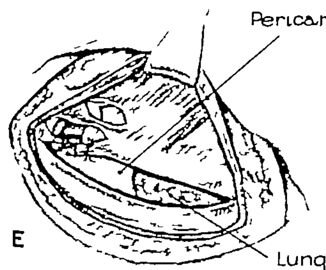
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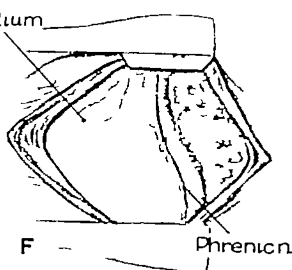

A


Mammary gland
B
Ant serratus m.
Pectoralis major


C
4th rib


D
Ext. intercostal m.
Pectoralis minor


E
Lung


Pericardium
F
Phrenic n.

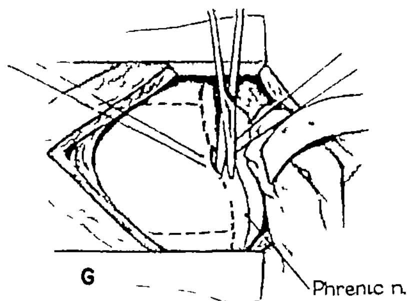
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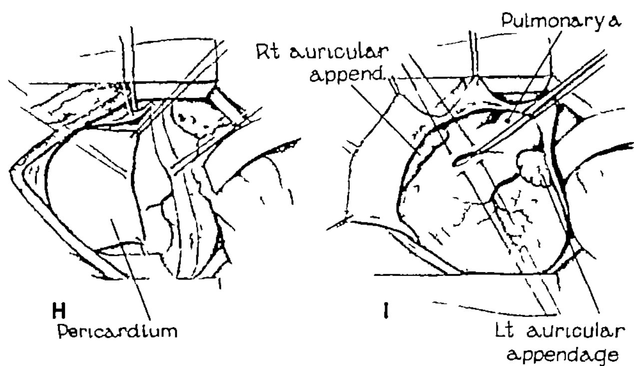
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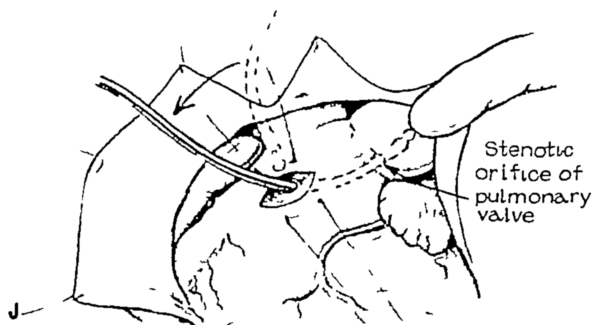
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G
Phrenic n.


Pulmonary a.
Rt auricular append.
H
Pericardium
I
Lt auricular appendage


Stenotic orifice of pulmonary valve
J

PULMONARY VALVOTOMY

A. The left side of the thorax is elevated slightly on a pillow and a transverse curvilinear inframammary incision is depicted.

B. The mammary gland is elevated the line of incision through the pectoralis major and serratus anterior muscles is shown in dotted outline

C. The incised muscle layers are retracted, and the underlying fourth rib and adjacent intercostal muscles are visible.

D The cephalad portion of the pectoralis major muscle is retracted upward to expose the pectoralis minor muscle, the angulated incision in the third costal cartilage the partially resected fourth costal cartilage, and the line of incision in the fourth interspace.

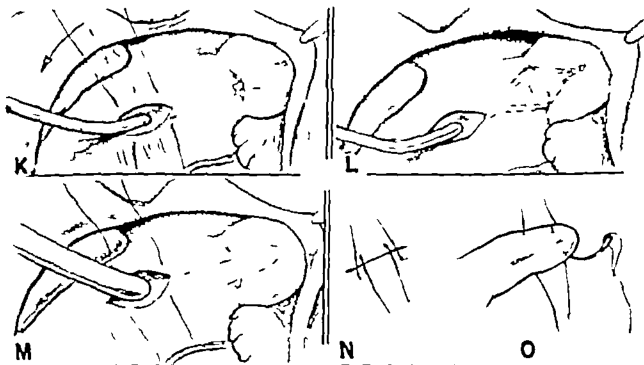
E. The left pleural cavity is entered, and the intercostal neurovascular bundle subjacent to the fourth costal cartilage is doubly clamped severed, and ligated Portions of the pericardium and left lung may be seen

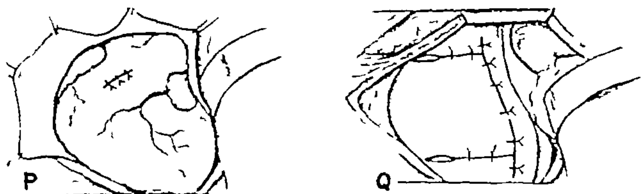
F The fourth and fifth ribs and the adjacent wound margins are retracted with a self retaining retractor to expose more completely the underlying pericardium and adherent left lung.

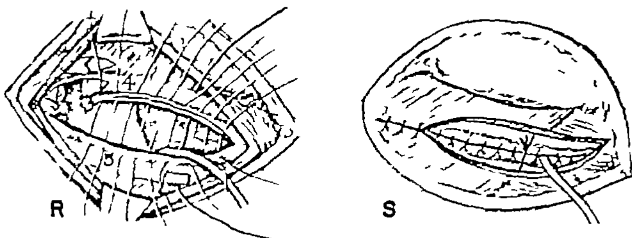
Discussion—Dr George H Humphreys II A congenitally stenosed pulmonary valve may be opened either by the closed method devised by Brock and depicted in Plates 107 through 109 or by the open method advocated especially by Swan and demonstrated in Plate 110 Although each method is well illustrated it should be noted that, even with the transverse double thoracotomy incision (Plate 110A) exposure of the heart and great vessels is not as complete as the illustration implies. When the valve is exposed in the open procedure, remnants of commissures may be seen and the surgeon may elect to restore a tricuspid valve rather than to make a simple transverse incision as illustrated (Plate 110) If the valve is irregularly distorted, care must be taken to avoid creation of incompetence. The valve annulus is frequently stenotic and will require dilatation in the open as well as in the closed procedure

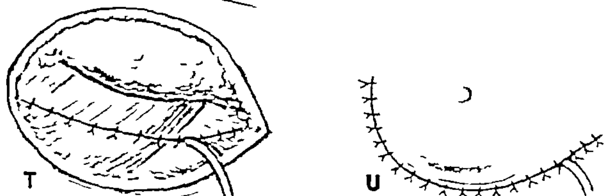
Consideration of the relative advantages and disadvantages of each method is important. The closed method of Brock is the older and there is a tendency among many recently trained surgeons to consider it obsolete However it has the advantage of greater simplicity and, when properly done in the appropriate cases, its results are equally good. Although published series do not show a greater mortality in the open procedure there is no question that the need for bilateral thoractomy and hypothermia or extracorporeal circulation add considerably to the risk of the operation and to the morbidity following it Against this is the fact that the closed procedure is blind " At best it cannot create a tricuspid valve and the successive passage of knives and dilators may cause unnecessary damage to the delicate valve structure. It is also more difficult to be certain of an adequate relief of the stenosis, and the incidence of persistent or recurrent stenosis is presumably higher

The open method has the advantage of direct vi-


K
L
M
N
O


P
Q


4
5
R
S


T
U

G The left lung, having been dissected from the pericardium, is covered by a moist gauze pad and retracted laterally The pericardial sac is entered between traction guy sutures of silk (000) medial to the phrenic nerve, and the opening in the pericardium is extended by scissor dissection to form a flap the boundaries of which are indicated in dotted outline.

H The formation of the pericardial flap is completed, and additional guy sutures of silk (000) have been inserted. Through the opening in the pericardium, portions of the anterior descending branch of the left coronary artery and the adjacent surfaces of the right and left ventricles are visible

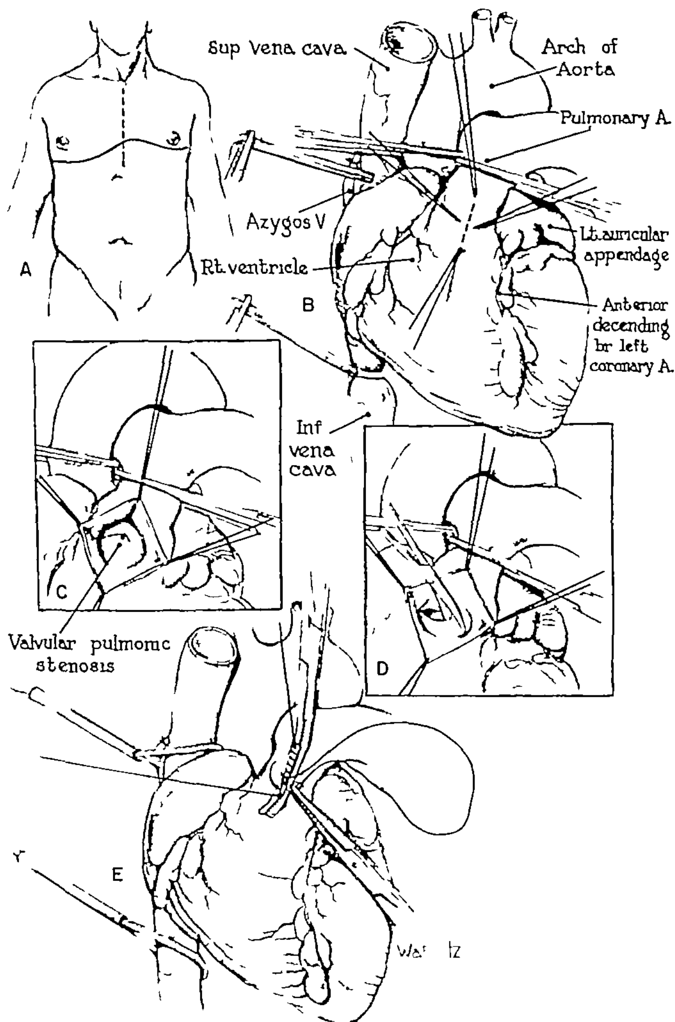
I The flap and cut margins of the pericardium are retracted, and the anterior surface of the heart and its related structures are exposed The anterior descending branch of the left coronary artery overlies the interventricular sulcus. An incision is being made through a portion of the wall of the right ventricle between guy sutures of silk (00) in close proximity to the pulmonary conus

J Close up view to show a malleable probe with a ball point protected tip being inserted by blunt force through the remaining portion of the incised wall of the right ventricle and through the stenotic orifice of the pulmonary valve into the lumen of the pulmonary artery The characteristic and diagnostic jetlike stream of blood flowing through the stenotic orifice of the fused pulmonary valve and the tip of the probe as shown may be easily palpated by digital indentation of the anterior wall of the pulmonary artery

DISCUSSION—DR. HUMPHREYS (cont.)

sion, with the possibility of more nearly complete restoration to normal by division in the commissures and tailoring of the cusps. It avoids a ventricular incision and, in cases of poststenotic dilatation of the pulmonary artery permits some correction of this abnormality by the "reefing" effect of the pulmonary artery closure Aside from the inherent risks of hypothermia, the use of inflow occlusion without extracorporeal circulatory support introduces a time limitation which puts an undesirable premium on speed. For this reason, as well as those discussed below there is an increasing tendency to use extracorporeal support rather than hypothermia in spite of the more elaborate technical problems and presumably greater risks of the method

The correction of associated anomalies, especially infundibular stenosis or septal defects, is impossible with the closed method or with the open method using hypothermia and inflow occlusion. These methods are appropriate, therefore, only in cases of isolated valvular stenosis. Preoperative diagnostic tests to exclude other anomalies are essential, but, even then, an associated anomaly may be overlooked. Since secondary procedures to correct septal defects carry a higher risk than their correction at the first operation, it is highly desirable to correct all of the existing lesions at the first procedure. If therefore, there is any suspicion that the problem includes more than a simple isolated valvular stenosis, complete cardiac exploration with extracorporeal support is indicated.


Sup Vena cava
Arch of Aorta
Pulmonary A.
Azygos V
Lt. auricular appendage
Rt. ventricle
Anterior decending br left coronary A.
A
B
Inf vena cava
C
D
Valvular pulmonic stenosis
E

K. The probe is withdrawn, and a small knife of the Brock type is inserted through the fused valves into the lumen of the pulmonary artery Between the insertion and withdrawal of instruments, bleeding from the ventricle is controlled by a combination of cross traction on the guy sutures and digital pressure over the incision

L. The cut in the valve is further enlarged by the insertion of first a medium and then a large Brock knife as depicted in dotted outline If preferred, a calibrated instrument as designed by Potts may be used

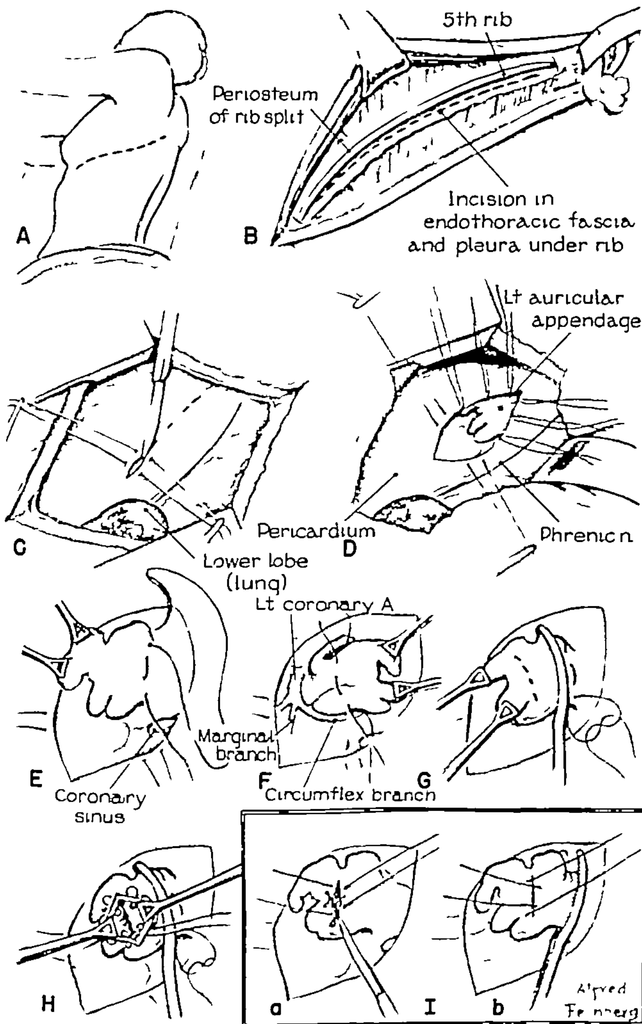
M A large urethral sound (29 F) is used to accomplish the final dilatation of the pulmonary valve orifice This instrument is preferred to a clamp because it is associated with less blood loss.

N O For the control of hemorrhage after the removal of the sound, the guy sutures on either side of the incision in the myocardium are crossed, and finger compression over the incision is applied. Closure of the incision is obtained with sutures of silk (00) inserted through the myocardium immediately beneath the finger

P Q The closure of the incision in the right ventricle is completed, and the pericardial flap is loosely approximated with interrupted sutures of silk (000). Small openings are present at either angle of the base of the flap to permit the escape of air and fluid collections into the pleural cavity

R The fourth and fifth ribs are approximated with one pericostal suture of heavy silk (No. 2) and a series of interrupted sutures of silk (000) in the intercostal muscle layer These sutures are all first inserted and individually tied. If preferred, heavy chromic catgut may be used for the pericostal suture The catheter (Foley No 14 F), for water seal drainage of the pleural cavity has its exit through the intercostal incision.

S T U The completion of the layer closure of the wound using interrupted sutures of silk throughout.


5th rib
Periosteum of rib split
Incision in endothoracic fascia and plaura under rib
A
B
Lt auricular appendage
Pericardium
Phrenic n.
Lower lobe (lung)
C
D
Lt coronary A
Marginal branch
Circumflex branch
Coronary sinus
E
F
G
H
a
I
b
Alfred Feinberg

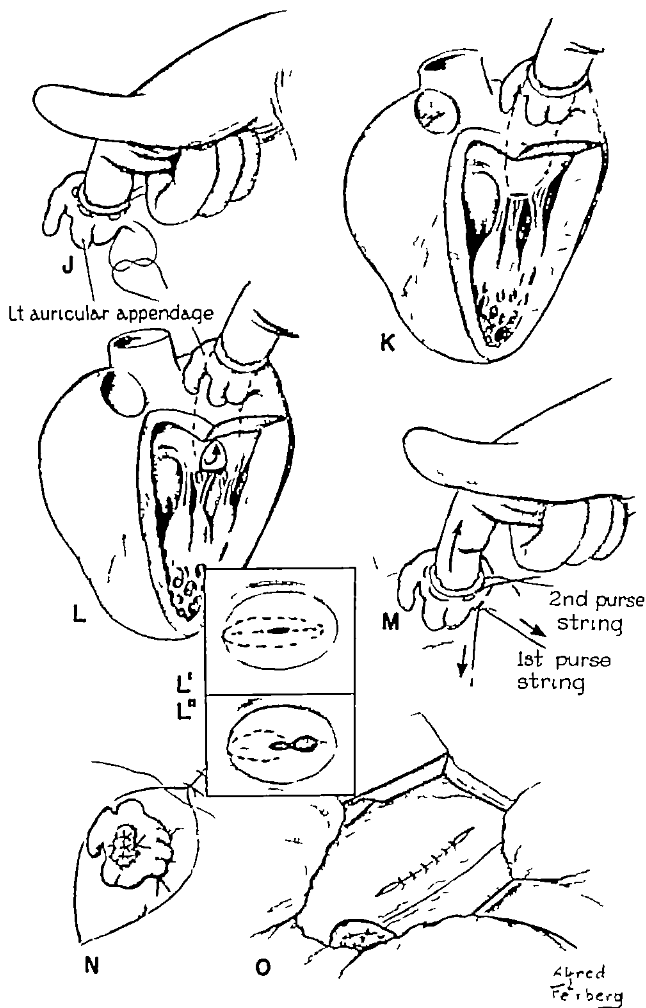
The following illustrations depict an open or direct technic which may be employed in conjunction with either hypothermia as shown or with the use of a pump oxygenator and total bypass of the heart.

A. In the exposure of the heart, a Duval–Barasty longitudinal sternal splitting incision (dotted line) or a trans-sternal cross-bow incision (solid line), entering the fourth interspace on the right and the third interspace on the left, may be employed.

B. Cardinal guy sutures of silk (0000) are inserted in the anterior wall of the pulmonary artery about the site of the incision (dotted line) to be made. Preliminary to making this incision, the superior and inferior vena cava are occluded with cotton tape ligatures and the base of the aorta and the pulmonary artery just proximal to its bifurcation are cross-clamped (Potts). To conserve time relative to the occlusion of the inflow tracts, it is preferable to first apply a clamp (Beck–Potts), in a longitudinal direction, to a segment of the pulmonary artery which is tented by the traction sutures previously inserted. An incision is then made between the guy sutures into the lumen of the occluded segment of the pulmonary artery Accordingly when the clamp is subsequently released immediate entrance into the lumen of the pulmonary artery and exposure of the valvular stenosis is obtained (C) Swan has advocated the application of a noncrushing clamp across the aorta about 2 cm distal to its origin and the injection of 0.5 mL of 1 4000 Prostigmin into the aorta between the valve and the clamp shortly following (30 seconds) occlusion of the inflow tracts. A duration of 15 to 20 seconds for this injection is advocated The aortic clamp is then removed, and occluding clamps are applied to the base of the aorta and the pulmonary artery (B, C) The Prostigmin is used to prevent ventricular fibrillation in the hypothermic patient.

C. The incision in the pulmonary artery is retracted by the guy sutures, and the stenosis of the pulmonary valve is visible.

D E. The pulmonary valvotomy is being completed by scissor dissection (D). Immediately following, the operative field is flooded with sterile saline solution, and the incised margins of the anterior wall of the pulmonary artery are approximated by the guy sutures preliminary to the application of the Beck–Potts clamp (E). The occluding tape ligature on the superior vena cava, the clamps on the aorta and the pulmonary artery and finally the occluding tape ligature on the inferior vena cava are released in the order mentioned to restore the circulation in the heart and great vessels. The incision in the pulmonary artery is then sutured (00000), first down (E) and then back, to be tied at its starting point.


J
K
Lt auricular appendage
L
L'
L''
M
2nd purse string
1st purse string
N
O
Alfred Feinberg

MITRAL COMMISSUROTOMY

A. The patient is placed in the direct right lateral prone position, and the thoracotomy incision immediately below the angle of the scapula is outlined.

B. The incision is deepened through the underlying musculature to expose the rib cage. A moist gauze sponge is inserted beneath the mobilized erector spinae group of muscles, and traction is maintained to demonstrate the angle of the fifth rib. The periosteum is removed from the lower half of the fifth rib anteriorly and the whole of the rib posteriorly after the manner of Brock. Posteriorly the endothoracic fascia and pleura are separated from the fourth and fifth ribs throughout the extent of the incision to obtain mobility of the adjacent rib cage. The fifth rib is retracted upward, and the incision in its bed is shown in dotted outline. In this technic the intercostal muscle bundle is not incised, and accordingly there is minimal bleeding.

C. The left pleural cavity is entered, and the fifth and sixth ribs are separated by a self retaining rib retractor. A portion of the pericardium either anterior or posterior (preferred) to the phrenic nerve is tented by traction sutures of silk (0000), and an incision is made into the pericardial cavity. The incision is extended upward, as indicated in dotted outline, and usually by scissor dissection to expose the anterior portion of the hilum of the lung and the dilated pulmonary artery.

D. Guy sutures of silk (000) are inserted through the cut margins of the pericardium, and, with traction on the sutures maintained a portion of the left auricular appendage is visible within the pericardial cavity.

E. The tip of the left auricular appendage is mobilized with Babcock clamps, and a pursestring suture of silk (0) on a swedged on minimum trauma needle is inserted. In the insertion of this suture, the full thickness of the wall of the appendage is included.

F. The insertion of the pursestring suture posteriorly is completed, and its relation to the subjacent circumflex branch of the left coronary artery is visible. This vessel is not seen at operation because of the overlying fatty tissue. The auricular appendage receives one and occasionally two arterial branches from the circumflex artery.

G. A Potts curved portacaval clamp is placed across the base of the auricular appendage immediately distal to the first pursestring suture and the site of incision in the terminal portion of the appendage is indicated. Resection of the tip of the appendage is no longer practiced.

H. After the incision into the lumen of the appendage is completed, the cut margins on either side are grasped in Babcock clamps and a second pursestring suture of silk (0) is inserted. In utilizing this open technic for the insertion of the second pursestring suture, one is assured that the opposite wall is not included in the suture. This technical error may occur in the closed technic, and the suture may be inadvertently cut when the incision is made into the lumen of the appendage.

I. Inset to show an alternate technic that is preferred in patients in whom a history of recent thromboembolic episodes is obtained.

a. Guy sutures of silk are first inserted. A small incision is made between the sutures into the lumen of the appendage, and clots, if present, are allowed to extrude.

b. Active bleeding is controlled by crossing of the guy sutures and application of the curved Potts clamp proximally. The operation is then continued as previously described.

ADDENDUM Transventricular dilatation is frequently employed to augment a finger fracture commissurotomy that might otherwise be less than optimum. This is particularly applicable for valves with rubbery elastic margins that stretch rather than divide before the exploring finger and for tough calcific valves. As illustrated in K, a dilator of the Tubbs or Gerbode type is inserted through a stab wound in the apex of the left ventricle. The surgeon, controlling the instrument with his left hand, manipulates the tip through the mitral orifice, where it is articulated against his right index finger within the left auricle. He then approximates the handles of the dilator to a preset gap achieving a fracture resulting in an orifice with a diameter of approximately two fingerbreadths, which may then be increased as desired by the intra auricular finger The dilator is withdrawn from the ventricle, and hemostasis is effected by the assistant, either by tying previously placed pursestring or interlocking sutures, or by finger compression while myocardial sutures are inserted. The left auricular appendage is managed as described for the standard finger commissurotomy Practiced coordination between the members of the operating team is essential.

Currently this type of "closed" cardiac surgery has been supplanted by "open" techniques, invoking cardiopulmonary bypass, when the problem involves the correction of mitral insufficiency or valve replacement. Since a wider commissurotomy for mitral stenosis could hardly be accomplished by an "open" method than that described above, there seems little indication at this time for cardiopulmonary bypass in the majority of cases of mitral stenosis. On the other hand, the equipment should always be available, on a standby basis at the very least, for all cases of mitral stenosis with substantial valvular calcification, where intra auricular thrombosis is suspected, or where the mitral valve has previously been subjected to surgery

J The right index finger is inserted through the incision in the left auricular appendage and into the lumen of the left atrium as the clamp on the appendage is released and subsequently removed. If necessary for the control of hemorrhage, though usually not, the pursestring suture may be drawn taut.

K L. The tip of the index finger in dotted out line may be seen first engaging the stenotic orifice and then producing the "finger frac ture" or avulsion tear through the antero-lateral commissure. In some instances a preliminary subvalvular mobilization of the leaflets by avulsion of the chordae ten dineae may be necessary before the com-missurotomy may be performed In other instances the use of a knife may be required. A unilateral, anterolateral commissurotomy may prove sufficient. However in general, a posteromedial commissurotomy should also be done. In the performance of a mi tral commissurotomy it is important that the split in the commissure extends out to the annulus of the mitral ring in order to obtain the maximum benefit of the opera tion For clarity the pursestring suture has been deleted.

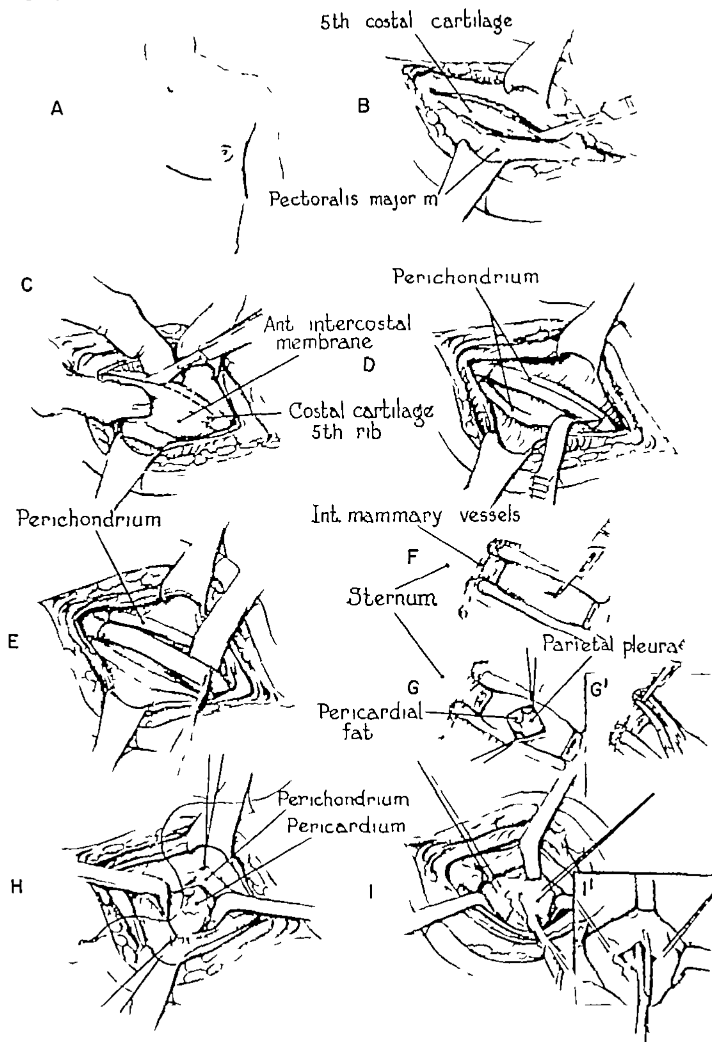
L The orifice of the mitral valve in the pres-ence of pure stenosis The dash and dotted outlines indicate the direction of the an-terolateral and posteromedial separation respectively of the fused valve leaflets

L The orifice of the mitral valve in the presence of a combination of stenosis and regurgitation. The typical "key hole" defect involving the aortic leaflet (baffle) is depicted. Through this defect, the typical regurgitant jet is readily palpable. In the presence of a combined lesion of the mi-tral valve a unilateral, anterolateral com-missurotomy only is preferred (dotted out line) because of the danger of increasing the regurgitant jet if an extension in a pos-teromedial direction is performed.

M. The index finger is withdrawn from the lumen of the left atrium as the proximal pursestring suture, followed by the second pursestring suture, is tightened and tied by the first assistant. If desired, a Rumel tourniquet may be employed for tighten-ing the first pursestring suture If one pursestring suture only is used, the clamp may be reapplied to the auricular appen-dage just above the purse string as the fin-ger is being withdrawn. In such instances, the use of the clamp is an extra safety fac tor in the prevention of hemorrhage.

N The approximation of the left auricular appendage following the tying of the two pursestring sutures and the closure of the incision in the auricular appendage with interrupted sutures of silk (00) are shown.

O The incision in the pericardium is par tially closed with interrupted sutures of silk (000) The cut margins are loosely approx imated, and small openings are present at either end of the incision to permit the escape of collections of both air and fluid into the pleural cavity

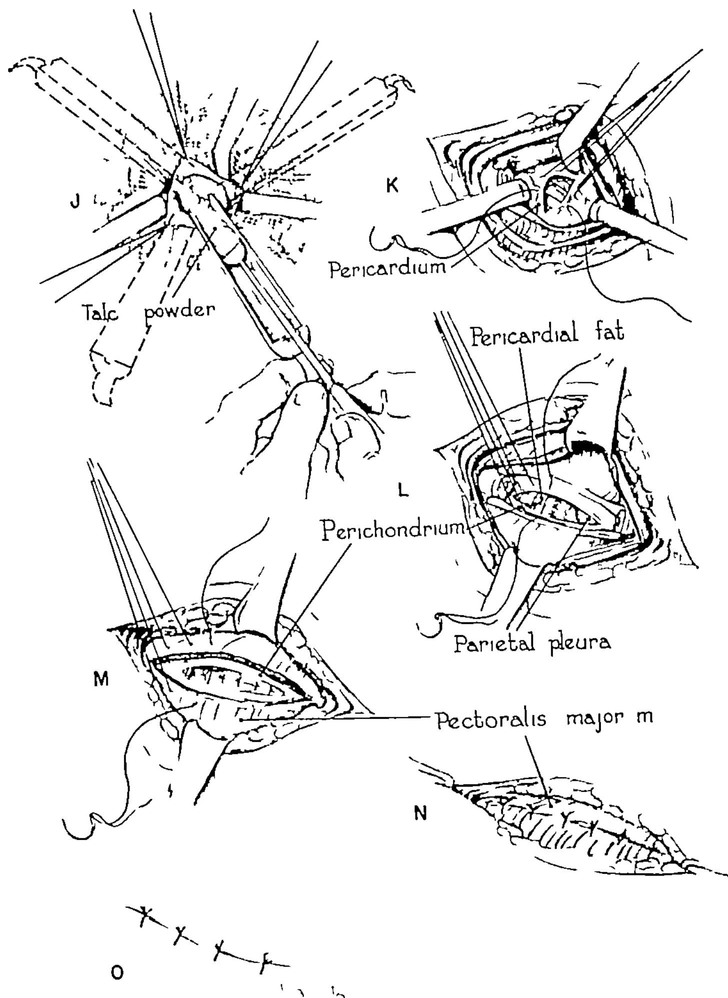

5th costal cartilage
A
B
Pectoralis major m
C
Ant intercostal membrane
D
Costal cartilage 5th rib
Perichondrium
Perichondrium
Int. mammary vessels
F
E
Sternum
Parietal pleurae
G
G'
Pericardial fat
Perichondrium
Pericardium
H
I
I'

DISCUSSION—DR. ELLIOTT S. HURWITT. This is an admirable technic for opening the stenotic mitral valve. As performed at the Montefiore Hospital, the operation includes some variations that have proven to be extremely helpful. Many patients with advanced heart disease tolerate the lateral decubitus position poorly and, occasionally, moderate elevation of the head and chest may be necessary to help prevent or control pulmonary edema. Consequently the position of the patient is about 30 degrees posterior to the true lateral, and the incision is placed more anteriorly than depicted (Plate 111A) extending from beneath the breast to below the angle of the scapula. Adequate exposure may be obtained by entering the pleural cavity through the fourth intercostal space.

The vertical pericardial incision is made considerably closer to the phrenic nerve than shown (Plate 111C, D). Additional exposure may be obtained by mobilizing the phrenic nerve and making a short T-extension in the pericardial incision over the base of the auricular appendage. If the pursestring suture (Plate 111E, F) is begun and ended in the medial wall of the appendage, it may be controlled by the first assistant. Coordinated teamwork is of paramount importance in the subsequent maneuvers.

Of the wide variety of clamps available for application to the auricular appendage, the Satinsky clamp with the Glover grip has been highly satisfactory. Traction sutures in the lips of the auricular incision have been of considerable help in facilitating the exposure and in controlling the auricle. As the operator disengages the auricular clamp with his left hand and insinuates his right index finger into the heart, the pursestring and traction sutures are manipulated by the assistants. The effectiveness of the intracardiac finger may be augmented by pushing against the operator's left hand, placed over the upper portion of the anteromedial wall of the left ventricle. Pericardial drainage into the pleural space is promoted by a looser pericardial closure than illustrated (Plate 112O). Underwater drainage of the pleural cavity is accomplished by an intercostal tube.

Although time may not be of major importance in the performance of many operations, survival of the desperately ill patient with tight mitral stenosis and severe pulmonary hypertension may occasionally depend on the shortest possible lapse of time between induction of anesthesia and opening of the valve. Under such circumstances, it is wise to defer the ligation or electrocoagulation of the blood vessels in the thoracic wall until one is ready to close the chest.


J
Talc powder
K
Pericardium
Pericardial fat
L
Perichondrium
Parietal pleura
M
Pectoralis major m
N
O

CARDIOPERICARDIOPEXY

A. The relatively short (8 to 10 cm) infra mammary incision directly overlying the left fifth interspace is depicted by the solid line

B. The skin incision is deepened through the underlying subcutaneous fatty tissue layer and the fibers of the pectoralis major muscle to expose the costal cartilage of the fifth rib

C D E. The perichondrium of the fifth costal cartilage is incised (C), and perichondrial flaps are elevated (D E) A long segment or the whole of the costal cartilage is then removed (E)

F G G¹ The bed or posterior perichondrium of the partially resected fifth costal cartilage is incised (F), and, after extension of the incision the cut margins are secured by traction sutures of 0000 silk (G). Beneath the incision, portions of the pericardial fat and parietal pleura are visible On occasions an opening may be accidentally made through the parietal pleura into the left pleural cavity If this should occur the opening is temporarily occluded with a moist gauze pad and the operation continued. At the completion of the poudrage, any pneumothorax present is removed by complete expansion of the lung while the chest wall incision is being closed. The inset (G) shows the internal mammary artery doubly clamped and being severed with a scalpel This is done routinely as a technical expediency in the performance of a cardiopericardiopexy If desired, the right internal mammary artery may be similarly clamped, severed, and ligated following the completion of the cardiopericardiopexy

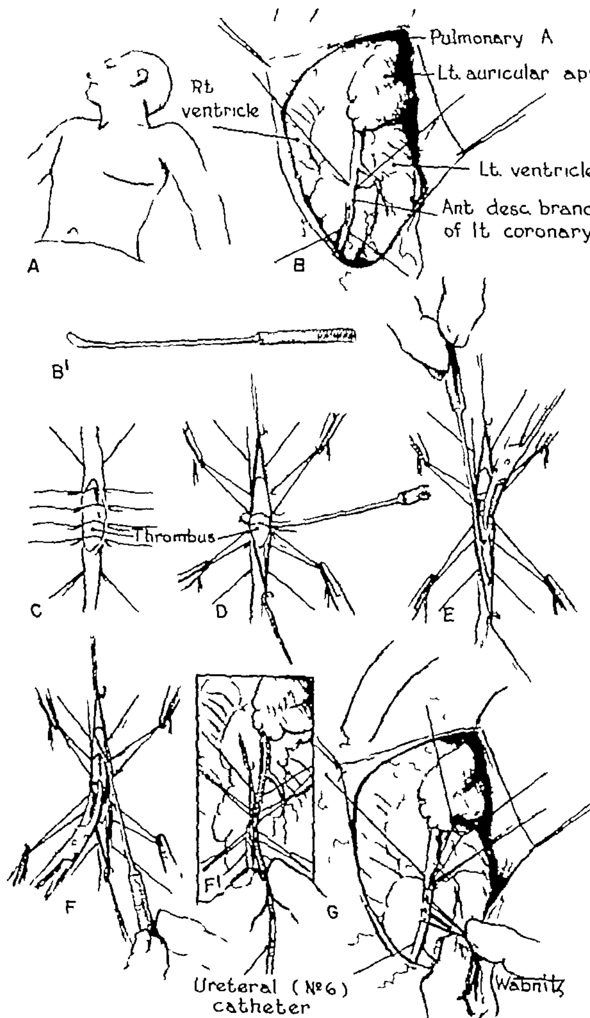
H I, I¹ Guy sutures of silk (00) are inserted in the parietal pericardium (H I) and, with traction maintained through the sutures, an incision is made into the pericardial cavity (I) and subsequently extended by scissor dissection (I¹)

DISCUSSION—DR. SAMUEL A. THOMPSON Cardiopericardiopexy is a method of myocardial revascularization, and, as such, it is essentially a form of myocardial surface irritation. It stimulates the formation of extracardiac as well as intercoronary collateral circulation. It is a simple operation and attended with a low surgical mortality The results over a period of 19 years have not been surpassed by any other method

The operation is entirely extrapleural, and the approach is over the left fifth costal cartilage (Plate 113A) This cartilage is stripped of its perichondrium and then removed completely from the sternal junction to the costochondral junction (Plate 113B C, D E) Opening the posterior perichondrium along the entire cartilage bed (Plate 113F G) exposes the thin fibers of the transverse sterni muscle. The fibers are gently elevated and severed, this exposes the pericardium and parietal pleura The parietal pleura is gently retracted laterally Occasionally in so doing, a small tear may occur in the pleura. No attempt should be made to repair this, but it should be temporarily *covered with a moist gauze pad and the operation* continued. Any pneumothorax which may be present is eliminated by complete expansion of the lung during closure of the chest wall structures. Ligation of the internal mammary artery (Plate 113G) which is done as a routine procedure in cardiopericardiopexy appears to increase the vascularity of the pericardium. If the right internal mammary artery is to be ligated, it can be done through a separate small incision in the right second intercostal space at the conclusion of the cardiopericardiopexy

The pericardium is elevated by two guy sutures (Plate 113H I) and a small incision is made. If there is an abnormal amount of pericardial fluid present or if the fluid is under increased pressure, each myocardial beat will force a small jet of fluid from the incision. The pericardial incision is enlarged in a direction parallel to the skin incision or in a transverse direction (Plate 113 I¹) and thorough aspiration of all possible pericardial fluid is attempted by means of a soft rubber catheter Frequent extra systoles may occur during this maneuver but are of no serious consequence. Thorough removal of the pericardial fluid is important since any quantity of residual fluid may wash the powdered talc to the dependent recesses of the pericardium, and the resulting myocardial surface irritation may be limited to the apical area instead of being generalized as is desired.

Magnesium silicate (U.S P talc) is the irritating material used to cover the epicardial surface of the heart This is widely distributed over the anterior surface and borders of the heart by means of a special powder distributor (Plate 113J) Depending upon the size of the heart, from 2 to 6 gm. of talc are


Pulmonary A
Lt. auricular ap
Rt ventricle
Lt. ventricle
Ant desc. branc of lt coronary
A
B
B'
Thrombus
C
D
E
F
F'
G
Ureteral (№6) catheter
Wabnitz

J Three guy sutures of silk (000) are inserted at equidistant points in the incised margins of the parietal pericardium, and the adjacent surroundings are walled off with moist gauze pads. Upward traction is maintained on the three guy sutures as the dry powdered talc is inserted into the pericardial sac and onto the epicardial surface of the heart covering the anterior surface and lateral margins The various planes in which the talc is deposited are indicated by the varying positions of the Thompson powder distributor (dotted out lines). The moist gauze pads about the oper ative field serve to prevent the deposit of talc onto the adjacent tissues.

K. Upon completion of the insertion of the talc (2 to 6 gm.) the moist gauze pads are removed, and the interrupted silk (000) sutures used to close the incision in the anterior parietal pericardium are inserted but not tied.

L. The closure of the pericardial incision is completed, and the insertion of the silk (000) sutures in the incised bed of the fifth costal cartilage is begun Portions of the pericardial fat and parietal pleura are also visible.

M N The closure of the incision in the costal bed is completed and the beginning of the insertion of interrupted silk (000) sutures to approximate the cut margins of the pectoralis major muscle and the underlying flaps of anterior perichondrium as a unit layer is shown (M) The completed closure is de picted in N

O The closure of the skin incision with inter rupted sutures of silk (000) completes the operation No drains are used.

DISCUSSION—DR THOMPSON (cont.)

used, and no attempt is made to cover the poste rior surface, as the beating of the heart will carry a sufficient amount to this area.

Upon completion of the powder distribution, quite frequently there is a decided drop in the patient's blood pressure The anesthetist should expect this, and, if it occurs, counteract it by the use of an intravenous pressor drug.

The pericardium is loosely closed with interrupted sutures, and the soft structures of the chest wall are closed in anatomic layers without drainage

In a period of almost twenty years, there has been no evidence that cardiopericardiopexy produces any degree of constrictive pericarditis or becomes avascular

DISCUSSION—DR. WILLIAM P. LONGMIRE, JR. With the assistance of Dr Albert Kattus of the Department of Medicine in the selection and preparation of patients, Dr Jack A. Cannon and I have operated upon five patients for severe incapacitating angina pectoris without evidence of myocardial infarction by the technic of direct vision coronary thromboendarterectomy Four of these patients survived the operative procedure Over a short period of time, all seemed to have been improved Improvement was noted, not only on the basis of subjective criteria, but also on the objective evidence of improved myocardial circulation this evidence was obtained from electrocardiographic tracings taken during exercise both before and after operation. Operations designed to improve myocardial circulation and relieve symptoms of angina pectoris are notoriously difficult to appraise, and this procedure must await further evaluation before its true efficacy and future status can be estimated. The early results are encouraging.

The operative procedure, as described by Dr Madden and also used by us in five patients, has proven that it is technically feasible to perform thromboendarterectomy of the major coronary vessels of the heart. Our limited experience has also demonstrated that it is possible to select patients for operation in whom the occlusive disease is limited to the major coronary vessels—i e vessels which may be attacked by direct surgical procedures. The crucial question to be answered by further observation pertains to the continued patency of these small vessels after thromboendarterectomy has been performed. The observation, as reported here by Dr Madden, that patency of the thromboendarterectomized vessel could be demonstrated some eight and-one-half hours after operation, supports the belief that the coronary arteries will remain patent following this procedure

In the procedure we have used, the patient is placed in the supine position, the thorax is entered through a bilateral thoracotomy incision made at the fourth interspace, and the sternum is divided. The pericardium is opened widely and all major coronary vessels are inspected and palpated. With this approach it is possible to open both the right main coronary artery and the left anterior descending artery This incision is not suitable for an approach to the left circumflex artery After the condition of the major vessels is evaluated, the smaller branches of the coronary arterial system are appraised by inspection and palpation. In only one case was there found to be slight "beading" of the smaller branches of the coronary arterial system. This was not felt to be sufficient reason, however to occlude these smaller branches. The epicardial fat is dissected away from the major coronary vessels In two cases, both the right main coronary artery and the left anterior descending artery were thromboendarterectomized in two cases, only the right main coronary was so treated and in one case the left anterior descending artery alone was operated upon As the epicardial fat is stripped away from the major vessels, the areas of disease inside the lumen of the vessel may be identified, owing to the marked adherence of the epicardial fat to the vessel at such a point.

In operations upon the right main coronary artery the vessel is exposed from its origin at the base of the aorta for a distance of approximately 3.5 to 4 cm., at which point it breaks up into its terminal branches The left anterior descending artery is exposed from its origin at the left circumflex artery peripherally until it also branches into several smaller vessels. After this artery is widely exposed a ligature is passed about the vessel at its origin and again peripherally or about the major peripheral branches A test period of complete occlusion of the vessel is then conducted by placing a "bulldog" clamp across the vessel for a period of six minutes. During this time, the color of the myocardium supplied by this branch is observed as well as the rate and rhythm of the heart. The heart action is monitored by the electrocardiogram We have not attempted to open any vessel if the heart did not tolerate complete occlusion of the vessel for a period of six minutes without showing any signs of regional cyanosis or arrhythmia.

A longitudinal incision is made in the vessel over the area which, by palpation, shows the most advanced disease, and the thickened intimal core is separated from the surrounding media and adventitia. It is not difficult to establish a good plane of cleavage between the structures and to isolate the obstructing core. Ligatures are then placed about the core at the proximal and distal ends of this incision An elevator similar to that described in Dr Madden's article, but modified so as to permit the instrument to be adjusted to different angles, is used to elevate the core from the media and adventitia of the vessel. If necessary additional longitudinal incisions are made in the vessel at the site of the major branches so that the branching core can be removed from these smaller vessels. When the limits of dissection with the elevator are reached, a circular stripper is inserted over the core and passed down the vessel between the core on one side and the media and adventitia on the other The stripper is carried as far distally as possible usually when the thickened intima thins out and is freed from the surrounding layers of the vessel, it divides readily and is removed from the vessel intact. A similar procedure is then repeated in the proximal end of the vessel. In the case of the right coronary the core is stripped up into the sinus of Valsalva at the mouth of the coronary artery In the case of the left anterior descending coronary the dissection is continued proximally into the lumen of the left circumflex artery In all cases, a vigorous pulsatile flow has been established from the proximal end of the vessel, and abundant back bleeding from the distal end of the vessel has been obtained A catheter has been inserted in the lumen of the coronary for the injection of heparin solution, as described by Dr Madden, but in more recent cases a small amount of powdered heparin was placed directly into the lumen of the vessel following thromboendarterectomy

The longitudinal incisions in the vessel are closed with continuous 000000 arterial silk sutures, the epicardial fat is resutured over the isolated artery and the pericardium is closed loosely with interrupted sutures of silk. Two catheters are placed in both pleural spaces and the thoracotomy incision is closed in layers in the usual fashion.

The one fatality in this series occurred in a 53-year old, white male patient, who was operated upon for severe incapacitating angina pectoris. In this case an uneventful endarterectomy of the right main coronary artery was performed During the subsequent removal of the thickened intima from the left anterior descending artery sudden irreversible dilation and asystole of the heart occurred Again, it should be stressed that this procedure is currently in the stage of evaluation, and its true place in the surgeon's armamentarium has not been clearly established.

A. The patient is placed in the supine position with the left side of the thorax slightly elevated. The anterolateral incision employed is indicated by the curvilinear dotted line.

B. The incised margins of the pericardium are retracted by guy sutures of silk (000) to expose the anterior descending branch of the left coronary artery This artery partially mobilized is encircled by two silk (No 1) sutures, between which the incision in the artery (dotted line) is subsequently made. The use of the encircling sutures in combination with finger compression for hemostasis is preferred to clamp (serrefine) occlusion

B[1] This is a sketch of the instrument of special design used for the dissection and mobilization of the thrombus.

C. The incision in the artery is completed, and the underlying thrombus which occludes its lumen is exposed Four sutures of silk (00000) are inserted through either incised margin of the artery and will be used for later closure of the incision after completion of the coronary thromboendarterectomy

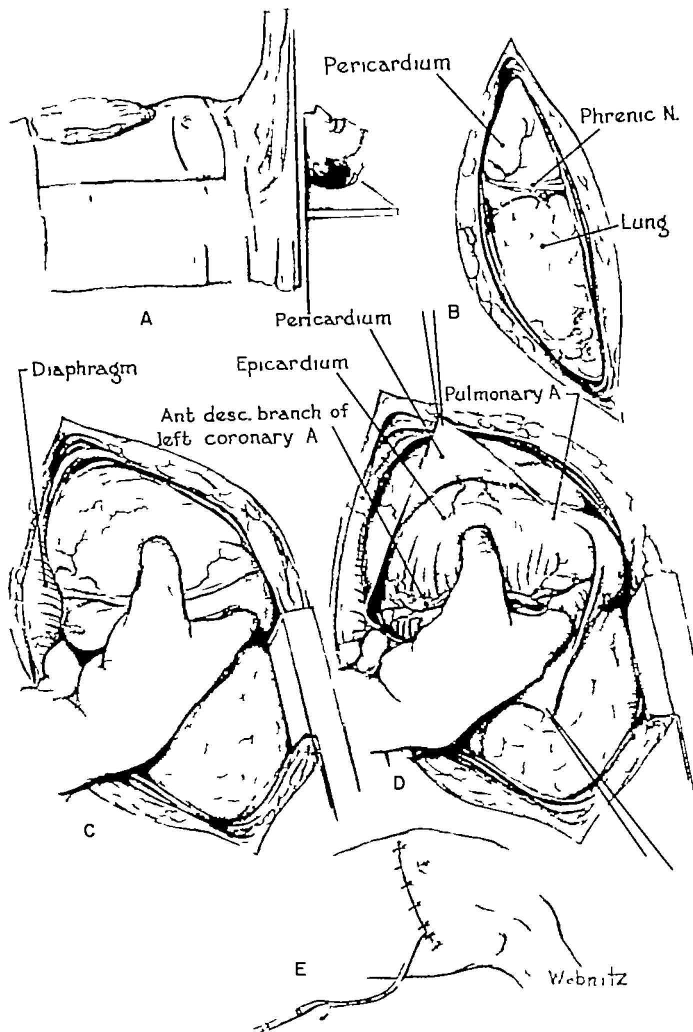
D The free ends of the four sutures previously inserted are separated into two groups upper and lower and grasped in clamps. The respective loops formed by the sutures are held in hook retractors and retracted cephalad and caudad respectively A segment of the occluding thrombus is separated from the arterial wall and elevated on the dissecting instrument. The dotted lines indicate the segment of the thrombus to be resected.

E. A segment of the thromb ted, and the transected end cauda d in a clamp for traction as dissection of this portion of the thrombus is being performed.

F Following the removal of the caudad segment of the thrombus, free retrograde bleeding occurred Similarly the transected end cephalad is grasped in a clamp for traction as dissection of this segment of the thrombus is being performed The thrombus was easily separated from the adjacent wall of the artery the lining of which was characterized by a healthy glistening sheen. This finding, in conjunction with the ease with which the thromboendarterectomy was performed, is believed indicative of the technical feasibility of the operation.

F[1] G Upon completion of the removal of the thrombus cephalad, a No 6 ureteral catheter was inserted into the lumen of the coronary artery and through its orifice into the lumen of the aorta As the catheter was slowly withdrawn, 10 ml. of a heparin-saline solution (100 mg of heparin in 250 ml. of saline) was injected When the withdrawal of the catheter was completed, a *forceful ejection of blood through the coronary arteriotomy* which reached the level of the skin drapes was observed Hemostasis was obtained by digital compression overlying the arteriotomy preparatory to approximation of the incised margins of the artery by traction upon the sutures previously inserted (G) As traction is maintained, the sutures are tied individually (G) to complete the closure of the coronary arteriotomy One additional suture was subsequently The use of this particular techni s the necessity for clamp occlusio ronary artery following the reest t of its blood flow This is consi sirable technical aid in the prev tasis thrombosis.

M nufactured by Edward Week New York


Pericardium
Phrenic N.
Lung
A
B
Pericardium
Diaphragm
Epicardium
Pulmonary A
Ant desc. branch of
left coronary A
C
D
E
Webnitz

solution of neoprene latex type 571* was injected (with the heart in situ) in a retrograde manner into the ascending aorta which was cross-clamped immediately distal to the site of injection. The heart and the occluded segment of the ascending aorta were removed, and, 24 hours later, dissection of the coronary arteries was performed. It was of interest to observe that the left coronary artery and its anterior descending branch and related collateral vessels were filled with red-colored neoprene latex. Contrariwise, the circumflex branch of the left coronary artery and the right coronary artery, which were not operated upon, were occluded by atherosclerotic thrombi. Through the center of each of these thrombi, a faint red line of the latex dye indicative of the size of the lumen within the thrombus was discernible. The result of this study was considered positive evidence of the continued patency of the left coronary artery and its anterior descending branch for the duration of the short period (eight-and-one-half hours) of survival of the patient following the coronary thromboendarterectomy.

The objection that the coronary arteries are too small to maintain the patency of the lumen when reestablished may prove more of a theoretical than a practical objection. Certainly the central head of arterial pressure within the aorta in relation to the orifices of the coronary arteries is much greater than the head of pressure in relation to the orifices of peripheral arteries of similar diameter. Accordingly it is believed a fallacy to negate the potential value of coronary thromboendarterectomy based on the poor results obtained in the performance of thromboendarterectomy in vessels of similar size in the peripheral arterial tree. Furthermore, despite the finding of extensive coronary atherosclerosis, as was present in this patient, the restoration of blood flow in one coronary vessel segment may prove beneficial. It is only by further cumulative experience that the practical value of coronary thromboendarterectomy will be either proved or disproved. Certainly the findings at operation in this particular patient proved that coronary thromboendarterectomy was technically a feasible operation. Following completion of the thromboendarterectomy it was indeed most impressive to observe the force with which the blood was ejected and the volume of flow through the coronary arteriotomy with each systolic contraction of the ventricles.

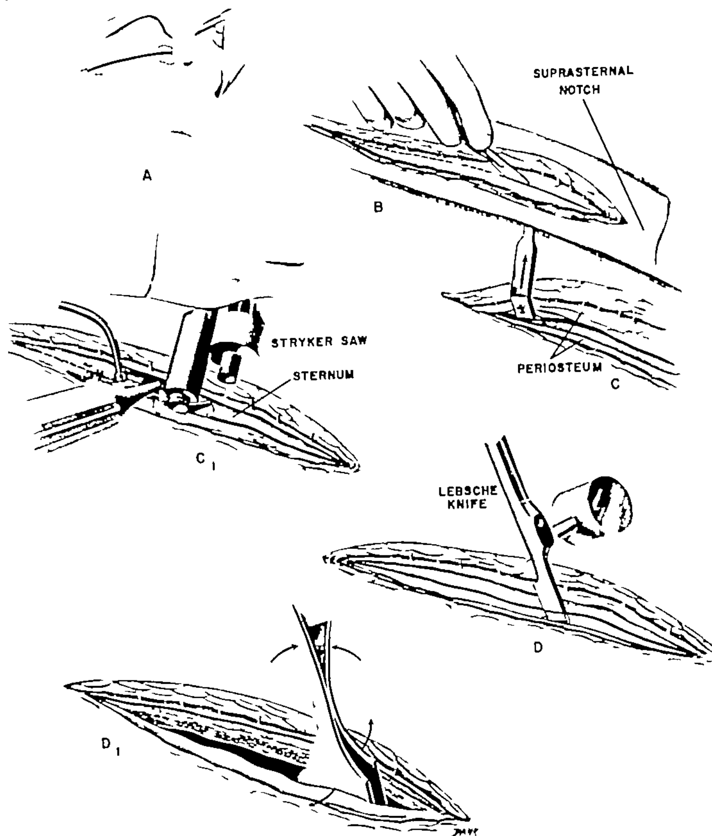
* Supplied through the courtesy of E. I. du Pont de Nemours & Co., Elastomer Chemicals Department, New York City.

DISCUSSION—DR. CLAUDE S. BECK. The problem of coronary thromboendarterectomy is not so simple as it appears on the surface. It is scarcely comparable to cleaning out debris from other arteries. If you put a string on the descending ramus of the left coronary artery and keep it there for a half hour or so and then release the artery, the probability is that the heart will fibrillate as red blood enters this ischemic muscle. This was a worry to me for many years because I and my associates in the laboratory always considered arterial blood to be good for the heart and never bad. Here we had an indication that arterial blood could kill the heartbeat. Finally the explanation became clear. If you anesthetize a dog and then clamp off the intratracheal tube for six to nine minutes, the dog becomes cyanotic and the heart becomes cyanotic. If you take a cotton electrode moistened with sodium chloride solution and sweep it across the ventricles, the electrogram is precisely the same as that obtained from a uniformly well-oxygenated heart. What does this mean? It means that the amount of oxygenated blood delivered to the heart has a relationship to the electrical condition, the electrical equilibrium, or electrical stability of the heart. A blue baby has a stable heart. If you put a string on a coronary artery, you create a blue or cyanosed area of muscle in a pink or well-oxygenated heart. If you canulate a coronary artery in a blue or asphyxiated heart and perfuse arterial blood into this artery, you create a pink area of muscle in a blue heart. Both of these hearts are electrically unstable and may fibrillate. The S–T segment of coronary artery and lifted electrical reactions from the heart, he called them "currents of injury." This concept is wrong. Creating pink and blue muscle in juxtaposition has nothing to do with "injury." This condition kills hundreds of thousands of men and women in this country every year. These are the people who die on the golf course, watching an exciting athletic contest, in the office, and so on. They are examples of self-electrocution of the heart. This often occurs in hearts that are too good anatomically to "die," and it often occurs without an infarct.

It is possible, therefore, to fibrillate the heart when one coronary artery is opened for a free flow of arterial blood and when the other two arteries are severely stenosed. Under certain conditions, red blood can kill the heartbeat.

This statement does not imply that there are no instances when the opening of an artery would not be beneficial to the heart. The writer has had numerous experiences in which the introduction of red blood would have been beneficial to the heart—cases in which the descending area of muscle would not contract because of inflow reduction. On many occasions, attempts were made to clean out the dis-
artery without success. T ... was in the
wall, and to remove ... required
of the entire wall ... The writer
upon 500 ... coronary
Almost al ... is in the
y ... of the cor
es—much too ... removal.
ease is rarely

Plate 117


A
B
SUPRASTERNAL NOTCH
C
PERIOSTEUM
STRYKER SAW
STERNUM
C_1
LEBSCHE KNIFE
D
D_1

CARDIAC RESUSCITATION

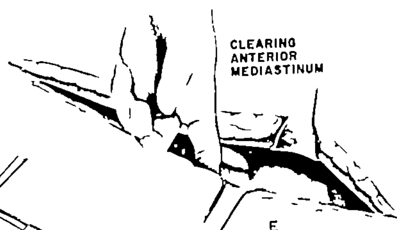
A. In this patient, acute cardiac arrest occurred during the course of an abdominal exploration The abdominal wound was covered by a moist pad and towel. The left anterolateral thoracotomy incision overlying the fifth interspace is depicted by the dotted line

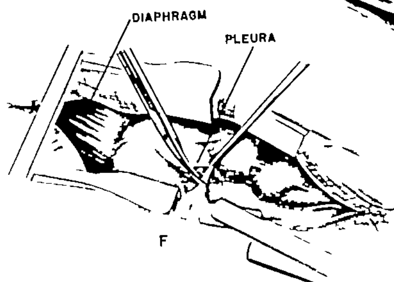
B. The left pleural cavity is entered with a bold sweep of the scalpel, and the underlying intrapleural structures are demonstrable.

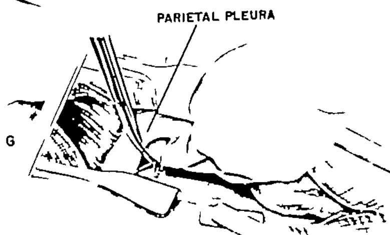
C D Immediate manual massage of the heart is performed and continued as a self retaining rib retractor (Tuffier) is inserted. Concomitant with massage, artificial respiration is maintained, preferably through an intratracheal tube, either by rhythmic compression of the rebreathing bag using 93 per cent oxygen and 7 per cent carbon dioxide or by the use of a mechanical ventilator such as the Jefferson type The placement of the patient in a 30-degree Trendelenberg position is a gravity aid in restoration of the circulation to the brain Initially the pericardium is not opened (C) because this would entail an unnecessary waste of time in the establishment of an artificial circulation to supply the immediate tissue needs of the body However if desirable subsequently the pericardium may be incised and intrapericardial massage continued (D) In the performance of manual massage, the heart is cupped in the hand with the apex directed toward the base of the palm. The fingers are inserted posterior and the thumb anterior to the heart, and rhythmic compression is performed. The rate of compression is 50 to 60 times per minute. Intermittently the epicardial surface of the heart is irrigated with warm saline solution as an aid to conduction. When a spontaneous rhythm is restored manual massage is discontinued momentarily and the cardiac activity is observed Frequently the heart rate will slow perceptibly and even come to a standstill unless manual massage is again performed. Under such circumstances calcium chloride (5 ml of 5 per cent solution) or epinephrine (1 ml of 1 1000 solution) may be used. Following the use of such drugs, the restoration and maintenance of a forceful cardiac rhythm frequently occurs. In the event of ventricular fibrillation, cocaine (10 per cent) may be used topically in conjunction with the continuation of manual massage, or an electrical defibrillator may be employed.

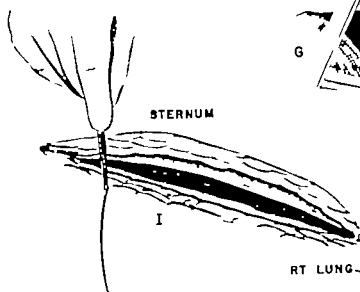
E. A layer closure of the thoracotomy incision is performed about a Foley catheter (No 16 F) which is used for water seal drainage of the pleural cavity If desired, the catheter may have its exit through a separate stab-wound drainage site below the incision.

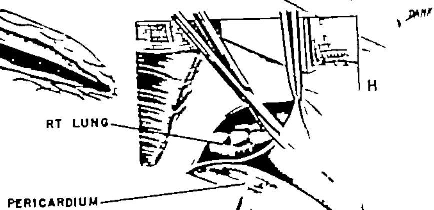
Plate 118


CLEARING
ANTERIOR
MEDIASTINUM
E


DIAPHRAGM
PLEURA
F


PARIETAL PLEURA
G


STERNUM
I


H
RT LUNG
PERICARDIUM

PERICARDIECTOMY

The patient, a 45-year-old Negro man, was admitted to the hospital because of dyspnea on exertion and moderate pedal edema. Seven years previously a stab wound of the chest overlying the precordium was sustained The immediate treatment was conservative, and the patient was discharged from the hospital six days later Subsequent stays in the hospital were required after one and one half years, three years, and five years, respectively because of symptoms indicative of right-sided heart failure Operation was advised on each occasion but was steadfastly refused

The last admission to the hospital was in September 1961 Dyspnea was severe on limited physical exertion but absent in full recumbency a characteristic symptom in patients with constrictive pericarditis Hydrothorax (right) hepatomegaly ascites, and pedal edema were moderate Interestingly the heart sounds were neither muffled nor distant. The blood pressure was 110/90 Roentgenograms of the chest, in addition to the right-sided hydrothorax, showed a calcification of the pericardium that encircled completely the cardiac silhouette when viewed in the lateral projection

The pressure in the left antecubital vein at the heart level was 245 mm. of water compared to the normal of 70-100 mm. The arm-to-lung (ether) and arm-to-tongue (decholin) circulation times were 25 seconds and 45 seconds, respectively compared to the normal of 7 12 seconds and 9-16 seconds.

The operation as illustrated was done under general endotracheal anesthesia and the patient actually improved as the decortication progressed The postoperative course was satisfactory and the patient was asymptomatic on discharge from the hospital three weeks after the operation The venous pressure and circulation times (ether and decholin) were normal.

Tuberculosis and viral infections are the major causes for constrictive pericarditis. The occurrence of this complication following a traumatic hemopericardium is relatively rare but does occur as demonstrated in the patient presented The rapidity of improvement and the complete relief of symptoms are believed related to the completeness of the decortication. Conversely a protracted convalescence is frequently the result of an inadequate removal of the scar rather than myocardial weakness secondary to a muscle atrophy of disuse Accordingly the importance of completeness in the performance of decortication of the heart for chronic constrictive pericarditis cannot be overemphasized

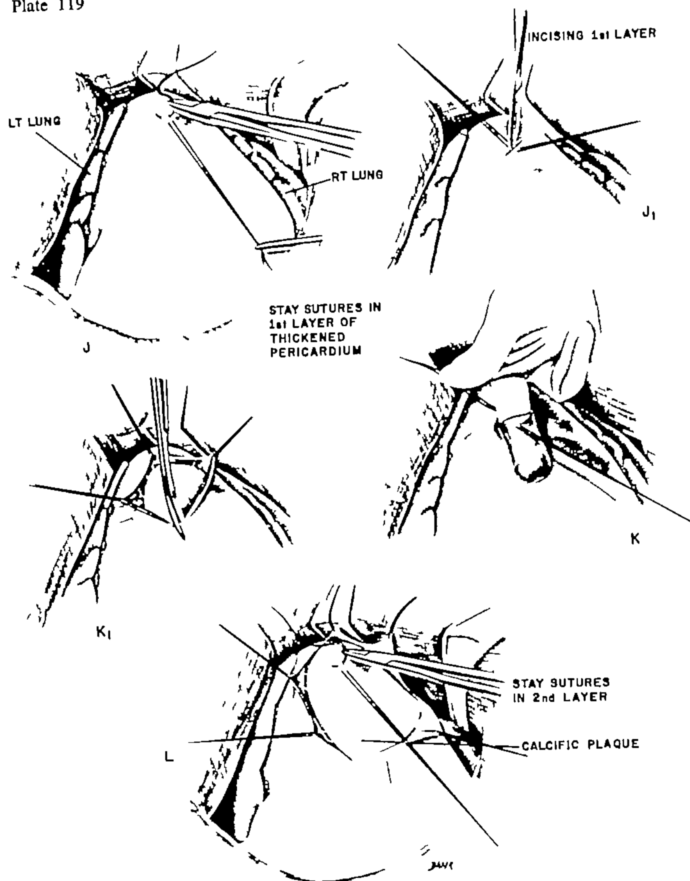
A. The patient is placed in the supine position, and the median sternotomy incision (Duval-Barasty) is depicted by the solid black line Subsequently an extension of the incision to the left (broken line) was required to obtain optimum exposure

B. The incision is deepened through the skin and subcutaneous tissue layers, and the periosteum overlying the sternum is incised.

C, C_1 The periosteum is separated from the sternum (C) the outer table of which is split longitudinally with a Stryker saw (C_1)

D D_1 The median sternotomy is completed with a Lebsche knife (D) and the cut margins are separated (D_1)

Plate 119


LT LUNG
RT LUNG
J
INCISING 1st LAYER
J1
STAY SUTURES IN
1st LAYER OF
THICKENED
PERICARDIUM
K1
K
STAY SUTURES
IN 2nd LAYER
CALCIFIC PLAQUE
L

E. By blunt digital dissection the loose fibroareolar attachments between the pericardial scar and the posterior surface of the sternum are separated.

F. The wound margins are retracted, and the mediastinal pleura is separated from the surface of the pericardium by scissor dissection.

G. An opening was inadvertently made in the mediastinal pleura, which is elevated on the index finger to facilitate its further dissection from the pericardium.

H. The separation of the pleura from the pericardium is completed, and the opening previously made in the pleura is extended cephalad with scissors. A portion of the atelectatic lung is visible within the right pleural cavity which contained 1500 cc. of serosanguinous fluid.

I. To obtain better exposure of the left border of the heart a transternal T extension of the incision into the fourth interspace is made.

Discussion—Dr. Emile Holman. The history of this patient's illness illustrates the not infrequent late development of cardiac constriction following the simple accumulation of blood in the undrained pericardial space, such as has been reported following an open heart operation, or a traumatic hemopericardium without laceration of the pericardium.

In effecting an adequate decortication the author has undertaken a so-called "radical" pericardiectomy the successive steps of which are clearly shown: the freeing of the anterior and posterior aspects of the apex first; the liberation of the left border of the heart down to the left hilum (having displaced the phrenic nerve from the pericardium); removal of scar beyond the inferior border of the heart, bringing into view the diaphragm and the inferior vena cava; extension of the decortication to free the base of the heart including the pulmonary artery, the superior vena cava, and finally freeing the right border of the heart down to the right hilar region. Adequate drainage must be provided both of the anterior mediastinum and usually the right pleural space to insure against the accumulation of blood clot over the surface of the denuded heart and recurrence of a contracting scar.

It should be recognized that the myocardial fibers and cardiac vessels are not always as clearly shown as illustrated (V) (W), particularly in a decortication performed in the presence of acute or chronic inflammation, but a complete and adequate removal of scarring over all possible critical areas is well stressed. Prompt reduction to normal venous pressure and circulation times provides convincing evidence of the adequacy of the decortication.

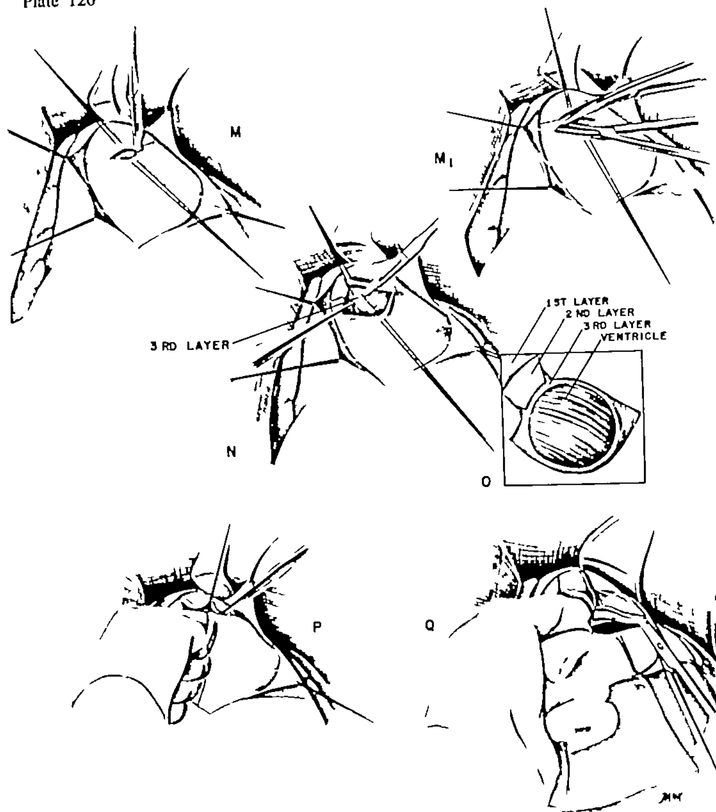
Discussion—Dr. Conrad R. Lam. The diagnosis in this case seemed to be well established by the history, roentgen finding of calcification of the pericardium and the markedly increased venous pressure. In some cases, confirmation by right heart catheterization will be indicated. Because of the lack of complete relaxation of the right ventricle, the diastolic pressure builds up quickly to equal the auricular pressure tracing.

The vertical sternum-splitting incision is definitely the incision of choice. I have found it satisfactory to split the sternum only to the third interspace, and to add a transverse incision to make a T-sternotomy. Since the great vessels do not need to be decorticated, this more conservative incision gives adequate exposure. Figures J through L show the use of traction sutures to hold up the thickened pericardium as it is separated from the underlying layer. I have preferred to grasp the edges firmly with clamps of the Allis type. It cannot be emphasized too strongly that a flap of at least one centimeter of pericardium should be left as dissection progresses so that it can be used to repair a tear in the ventricle if necessary. I believe that I have made an opening into the right ventricle in two-thirds of my cases, and in all the hemorrhage was easily controlled.

Figures M-O show that it was necessary to remove three layers of cortex before the myocardium of the right ventricle was completely exposed and freed. It has seemed to me that most of my cases have had two layers rather than three. At any rate, it is easy to see when he has done the proper amount of "peeling."

The extent of the decortication as shown in W seems adequate. Some previous writers on the subject of pericardiectomy for constrictive pericarditis have urged that the pulmonary veins be exposed. I am sure that manipulations this deep through the midline incision will result in injury to the phrenic nerves and perhaps auricular or venous bleeding which might be difficult to control. We have never failed to achieve what appeared to be a perfect clinical result when there was a complete decortication of the right ventricle and right auricle, and at least a partial decortication of the left ventricle.

Plate 120



J J_1 Traction sutures of silk (000) are inserted through the thickened pericardium overlying the apical region of the left ventricle (J) and the pericardial scar is incised (J_1) between the sutures. Dissection is first begun over the left ventricle. This is based on the reasoning that the muscle fibers of the encased heart have undergone an atrophy of disuse. Accordingly if the thinner walled right ventricle were freed first, acute myocardial rupture might be more apt to occur with sudden distention of the ventricle with blood. Another objection to freeing the right ventricle first would be the potential hazard of producing acute pulmonary hypertension and resulting pulmonary edema. Blood would be permitted to enter the lungs but its egress would be prevented by the compression scar about the left ventricle.

K, K_1 By blunt digital dissection a cleavage plane is entered beneath the first layer of the thickened pericardium (K) and the opening in this layer is enlarged by scissor dissection (K_1)

L. A second set of guy sutures (000 silk) is inserted in the second layer of the pericardial scar for traction. A portion of an adjacent circumscribed calcific plaque is visible

Discussion—Drs. William H Muller, Jr., and Gardner W Smith. Despite the fact that pericardiectomy for chronic constrictive pericarditis is one of the oldest operations in cardiac surgery the surgical technics remain controversial and are, to some extent, a matter of the personal judgment of the surgeon.

The case report presented in the text is typical in many respects, and the traumatic basis is certainly not unusual. Although constrictive pericarditis is commonly thought of as a sequel to tuberculous pericarditis, blunt and penetrating traumatic injury is being implicated with increasing frequency. The viral cause of benign pericarditis is still not thoroughly documented and the progression of this disease to the constrictive phase is difficult to prove. Rheumatic carditis seldom produces constrictive pericarditis. A great variety of other etiologic factors have occasionally been demonstrated, but the largest group of cases must still be classified as idiopathic.

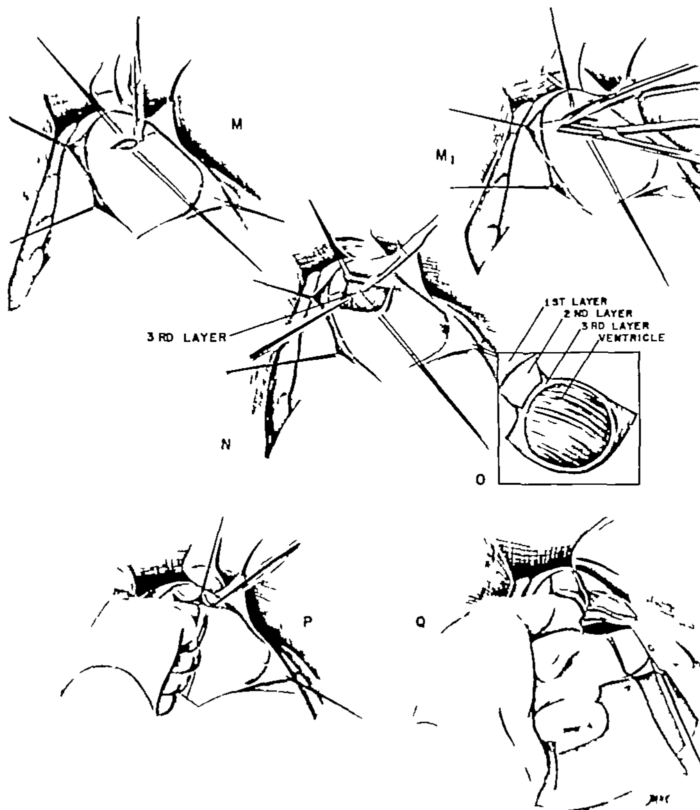
A feature which bears emphasis is that these patients do not suffer from true congestive heart failure and digitalis therapy is of no benefit. Indeed, the preoperative use of this drug may be detrimental since it tends to slow the compensatory tachycardia, may decrease the stroke volume of the normal myocardium and often makes arrhythmias during operation more difficult to control. Thus, it is restricted to patients with auricular flutter or fibrillation whose ventricular response must be controlled. In contradistinction to these preoperative considerations, digitalis is essential during the postoperative period since a certain degree of myocardial atrophy is often present resulting in true congestive failure.

The incision represented in A is widely accepted. Greater exposure can be obtained if the skin and linea alba are divided inferiorly to a point one third of the way to the umbilicus. The Stryker saw facilitates accurate clean division of the sternum. Bleeding from the sternal periosteum may be diminished by dividing this structure with the cautery and the problem of hemorrhage from the sternal marrow can be controlled with bone wax.

Many other approaches have been used but the most useful of these are the bilateral anterior thoracotomy and the left anterolateral thoracotomy. The former incision is most successful if made through the fifth intercostal space on the left and the fourth intercostal space on the right with an inverted V-shaped transverse division of the sternum. In recent years, the left anterolateral thoracotomy in the fifth intercostal space has been used frequently in this clinic. Excellent exposure of all but the superior vena cava and right atrium can be obtained and a thorough decortication performed. Most of the right atrium can be decorticated if the heart is slightly displaced. This incision is clearly less extensive and traumatic than either the median sternotomy or the bilateral anterior thoracotomy

Certain features of the dissection in plate II should be emphasized. It is often impossible to avoid entering both pleural spaces and no effort should be expended to this end. The pleuropericardial separation is performed laterally to expose the phrenic nerve on either side, and on the left this structure should be elevated from the underlying pericardial scar and retracted from the field to avoid injury

As regards the decortication itself all layers of thickened pericardium must be removed for a successful operation. This usually includes distinct pericardial and epicardial surfaces which often have a tempting cleavage plane between them.


M
M1
3 RD LAYER
1 ST LAYER
2 ND LAYER
3 RD LAYER
VENTRICLE
N
O
P
Q

M M$_1$ The second layer is incised between the guy sutures (M) and the opening is extended by scissor dissection (broken lines) toward the apex of the heart (M$_1$) The circumscribed calcific plaque cephalad is again visible

N Through the opening in the second layer of the scar the start of the incision (broken line) in the third layer is shown. On an anatomic pathologic basis one would expect to have only two layers within a pericardial scar—viz. visceral and parietal However in this patient there were three distinct cleavage planes between the surface of the heart and the overlying scar It was not until the third layer was incised that a free expansile pulsation of the left ventricle was visible The importance of removal of the whole thickness of the scar cannot be overly stressed.

O. The inset shows a circumscribed area of the freed apical portion of the left ventricle and the three layers of the pericardial scar

P A mobilized portion of the whole thickness of the pericardial scar is elevated on *the left index finger and incised.*

Q By blunt digital dissection the whole of this apical region of the heart, including its diaphragmatic and posterior surfaces, is freed from the scar which is then excised with scissors The removal of the scar posteriorly is believed important to permit the maximum filling and emptying of the ventricle with each diastole and systole respectively

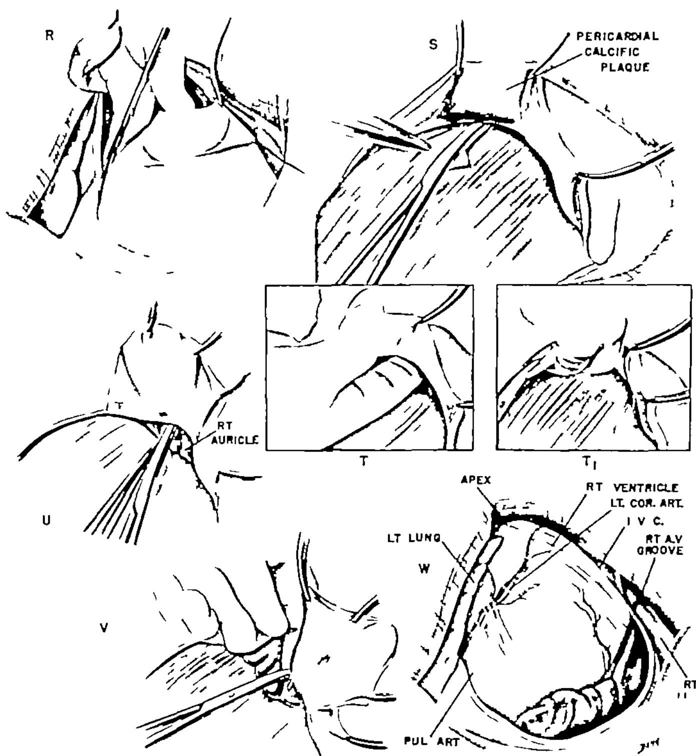
DISCUSSION—DRS. MULLER and SMITH (cont.)

Judgment as to the depth adequate for a complete decortication is determined by observing herniation of the myocardium through the defect created in the encasing scar

The admonition to begin the dissection over the left ventricle based largely on theoretical grounds, is commonly accepted and may be valid in some cases. It is prudent however to avoid the interventricular groove and its associated anterior descending coronary artery during the early phase of decortication before a well-defined plane is established at the myocardial level The importance of maintaining all the pericardial flaps until the dissection is complete should be stressed since they are invaluable in repairing myocardial rents and in controlling bleeding

The question of the extent of decortication is unsettled Areas of deep myocardial infiltration by calcified plaques should be isolated and remain in place especially in the region of the coronary arteries There is general agreement that the anterior surfaces of both ventricles should be decorticated completely and as far laterally as the left phrenic nerve The peel should be removed from the entire apex and from the diaphragmatic surface, even though proof is lacking that scarring in this area interferes mechanically with ventricular systole The importance of caval and right atrial obstruction was overemphasized during the early history of pericardiectomy in this country Significant caval obstruction has not been demonstrated by cardiac catheterization or by angiocardiography nor has this phenomenon been found to occur experimentally Isolated instances at operation have been described in which significant narrowing of the cavae was believed to be present. Furthermore, cases of impairment of function of the left atrium, the pulmonary veins the great vessels at the base of the heart and the left atrioventricular groove have been recorded The latter is further documented by catheterization evidence of functional mitral stenosis in some cases. Therefore, the question of decortication of the atria, the cavae, the great vessels and the pulmonary veins is still conjectural There is little doubt that such an extensive pericardiectomy increases the operative risk, and the decision as to decortication in these areas must remain the judgment of the surgeon

The control of arrhythmias during pericardiectomy should be mentioned As previously suggested, the avoidance of preoperative digitalis will reduce the risk of intractable arrhythmia. The pre


R
S
PERICARDIAL
CALCIFIC
PLAQUE
RT
AURICLE
U
T
T_1
APEX
RT VENTRICLE
LT. COR. ART.
I V C.
RT A.V
GROOVE
LT LUNG
W
V
RT
PUL ART

$M\ M_1$ The second layer is incised between the guy sutures (M) and the opening is extended by scissor dissection (broken lines) toward the apex of the heart (M_1) The circumscribed calcific plaque cephalad is again visible

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Discussion—Drs Muller and Smith (cont)

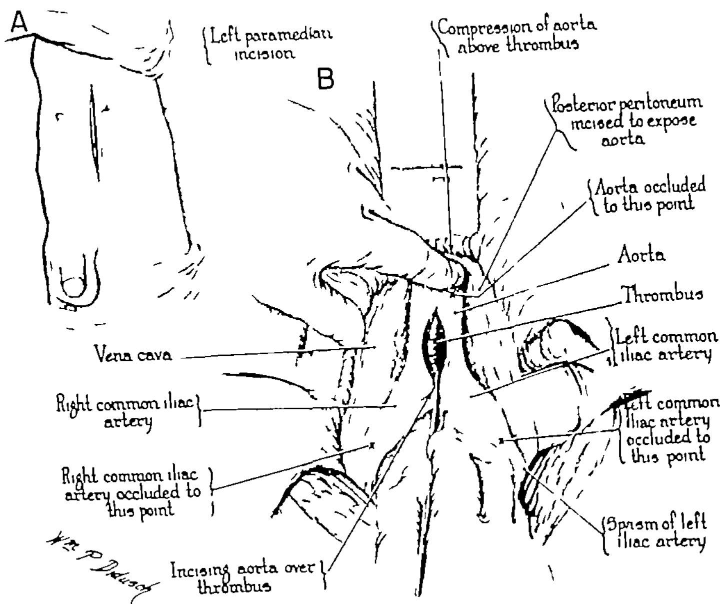
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Plate 122


A
Left paramedian incision
B
Compression of aorta above thrombus
Posterior peritoneum incised to expose aorta
Aorta occluded to this point
Aorta
Thrombus
Vena cava
Left common iliac artery
Right common iliac artery
Left common iliac artery occluded to this point
Right common iliac artery occluded to this point
Spasm of left iliac artery
Incising aorta over thrombus

R. The surgeon is now on the left side of the operation table. In this position the pericardial dissection cephalad is facilitated. A mobilized segment of the thickened pericardium, well beyond the area of the calcific plaque, is elevated on the index finger and severed with scissors in the direction indicated (broken line). When a calcific plaque is present, one should consider always the possibility that it has infiltrated the wall of the underlying myocardium. If this is proved, the surrounding pericardial scar should be tailored about the plaque leaving it as a calcific island on the surface of the heart. An attempt to excise the plaque would risk the danger of severe or even fatal hemorrhage.

S. The cut margin of the mobilized portion of the pericardial scar is clamped and retracted upward to show the dissection beneath the plaque that did not infiltrate the myocardium. Dissection of the scar is aided by counterpressure on the surface with the use of moist cotton "paddles." The maintenance of a free flap of pericardium during the dissection is helpful for hemostasis in the event of accidental bleeding. Should it occur the mobilized pericardium may be replaced immediately over the bleeding site and sutured in place.

T, T_1. By wide digital dissection beneath the scar the right border of the heart, including the area about the inferior vena cava, is freed (T) and the excision of the scar is continued toward the encased right auricular appendix (T_1).

U. A flap of thickened pericardium is maintained while the right auricular appendix, depressed by counterpressure over a moist cotton "paddle," is being freed by scissor dissection.

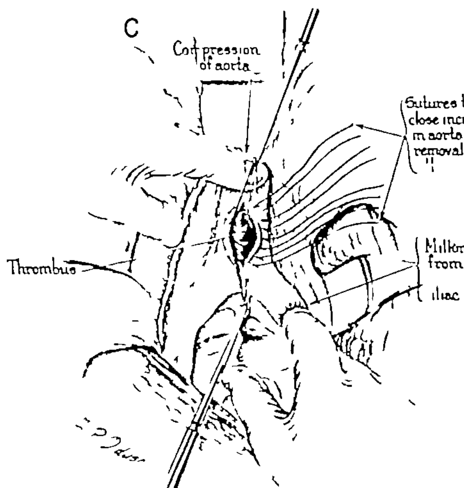
V. By combined blunt digital and scissor dissection the remaining attachments of the scar to the auricular appendix are severed to complete the decortication of the heart. It is frequently argued that the thin-walled auricular appendix should not be freed because of the danger of hemorrhage. In this patient the plane of cleavage was easily entered and the scar readily removed.

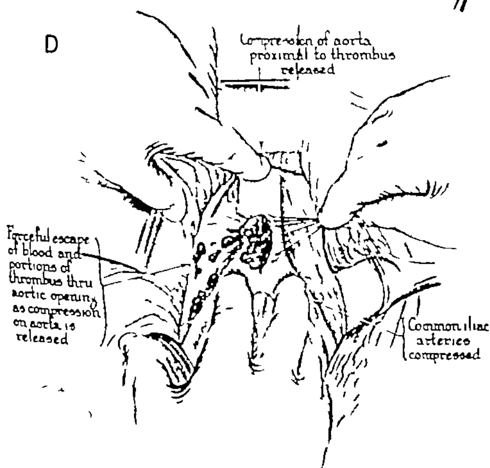
W. The operative field upon completion of the pericardiectomy is shown. The degree of clinical improvement postoperatively is believed directly proportional to the completeness of the operation. The decortication should include the anterior surfaces of both ventricles, the diaphragmatic and posterior aspects of the apex, the atria, the pulmonary hilar regions, the base of the pulmonary artery, and the areas about the entrance of the superior and inferior vena cava. The wound is closed and the pleural cavities drained as depicted in the illustrated technic for thymectomy.

DISCUSSION—DRS. MULLER AND SMITH (cont.)

operative use of quinidine and the topical use of procaine or lidocaine have been widely tested and are found to be ineffective. The intravenous use of atropine sulfate will often control sinus bradycardia, and intravenous lidocaine helps to reduce myocardial irritability manifested as ventricular ectopic beats or as ventricular tachycardia. However, the control of arrhythmias is best accomplished by rest periods during the dissection, allowing the irritability to subside.

As regards the results which can be expected from pericardiectomy for constrictive pericarditis there have been no recorded instances of recurrence of pericardial scarring. Thus, if re-exploration is required because of an unsatisfactory result, any residual scar tissue is evidence of a previously incomplete decortication. The over-all operative mortality is 12 to 15 per cent, but this increases to the vicinity of 30 per cent if a second procedure is required. Good results can be anticipated in 75 per cent of the patients, with 57 per cent cured and an additional 18 per cent improved. Late deaths account for 7 per cent of the remaining cases and 5 per cent of the cases will receive no benefit from surgery. Appropriate antibiotic preparation and early operation obviates myocardial atrophy and yields better results. It is apparent that a properly [illegible] pericardiectomy can offer eminently s[illegible] results.


C
Compression of aorta
Sutures to close incision in aorta after removal
Thrombus
Milking from
iliac


D
Compression of aorta proximal to thrombus released
Forceful escape of blood and portions of thrombus thru aortic opening as compression on aorta is released
Common iliac arteries compressed

AORTIC EMBOLECTOMY

A. A left paramedian incision as depicted is preferred The incision extends approximately one third above and two thirds below the level of the umbilicus.

B. The peritoneal cavity is entered, the intestines are displaced upward and the posterior parietal peritoneum is incised to expose the lower portion of the abdominal aorta and its bifurcation The lumen of the aorta is occluded by digital compression, and the anterior wall of the aorta overlying the contained thrombus is incised. The thrombus which extends distally into both common iliac arteries is herniated partially through the incision This herniation of the thrombus causes an eversion of the incised margins of the intima and facilitates the subsequent insertion of the everting mattress sutures of fine (00000) silk. The spasm of the left iliac artery distal to the thrombus is visible

If for technical reasons the use of the index finger proves unsatisfactory a 10-inch length anatomic tissue forceps may be conveniently substituted.

The surgical approach to the lower portion of the aorta and its bifurcation may be extraperitoneal, transperitoneal, or retrograde. The transperitoneal approach, spinal anesthesia being used, is preferred. Although objected to by many the advantages are believed to exceed the proclaimed disadvantages.

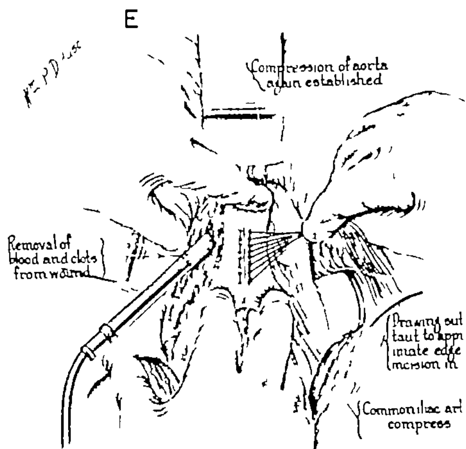
The basic principles that are believed to underlie the successful surgical removal of an arterial embolus are (1) an early operation, preferably within the first eight hours (2) an adequate surgical exposure (3) the production of a minimum of trauma, particularly in the intima (4) the interruption of the circulation for a minimum period after the thrombus is removed

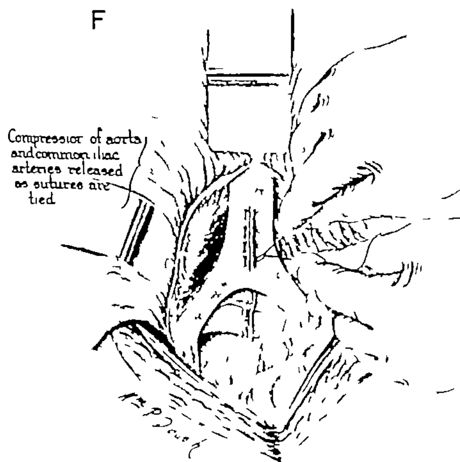
In most of the surgical technics commonly employed for aortic embolectomy mechanical devices or tape ligatures are used to occlude the aorta proximal to the blockage and the common iliac arteries distally In the majority of patients with a saddle occlusion of the abdominal aorta, varying degrees of atherosclerosis are present. This is the reason why it is believed that most of the so-called saddle emboli in patients in the arteriosclerotic age group are in reality autochthonous thrombi The degenerative changes occur predominantly in the posterior and lateral walls of the aorta The occlusion of the lumen of the aorta by a mechanical device, a traction tape ligature, or an occluding tape ligature may produce a fracture of an atherosclerotic plaque with resultant injury to the intima. This predisposes to the formation of a local thrombus. In general, the use of such methods for hemostasis requires the complete mobilization of the distal portion of the abdominal aorta and its bifurcation A notable exception is the technic described by Linton This mobilization of the aorta prolongs the operation, risks the danger of dislodging a portion of the thrombus to form an embolus, and increases the likelihood of troublesome hemorrhage.

In the technic illustrated, mechanical devices or tape ligatures for hemostasis are not used. Instead, for this purpose, the left index finger of the assistant or an anatomic tissue forceps 10 inches in length is employed. Protective rubber shods predispose to slipping of the forceps off the walls of the aorta and are not used The use of the index finger or tissue forceps produces a minimum of tissue trauma, does not require the mobilization of the aorta and permits the immediate release or application of a compression force to the aorta, a desired technical aid. Furthermore, a delicate adjustment of the compression force applied may be obtained The same principles of technic illustrated are employed for the removal of the more peripherally located arterial

Thrombi which are formed where found

li


E
Compression of aorta again established
Removal of blood and clots from wound
Drawing out taut to appr imate edge incision in
Common iliac art compress


F
Compressor of aorta and common iliac arteries released as sutures are tied

C. Digital compression of the aorta is maintained proximal to the thrombus, and the untied strands of silk sutures are retracted on a nerve hook to allow the free escape of the blood clots. The thrombus first in one then in the other common iliac artery is "milked" upward and extruded through the opening in the aorta. The demonstration of free retrograde bleeding following this maneuver indicates the patency of the collateral vascular channels below the site of the aortic occlusion, which is a favorable prognostic sign

D. The common iliac arteries are occluded by digital compression immediately distal to the bifurcation of the aorta either by the right hand of the first assistant or the left hand of the surgeon as the digital compression of the lumen of the aorta proximal to the thrombus is slowly released. Generally the pressure in the aorta is sufficient to expel forcibly through the aortic incision the remaining portion of the thrombus. If not, the thrombus may be evacuated by "milking" it downward from above by gentle digital compression The discharge of the thrombus is followed by a forceful pulsatile flow of blood the control of which is being initiated by traction on the untied strands of the silk mattress sutures. The digital occlusion of the common iliac arteries is done to prevent the dissemination of thromboemboli into the peripheral arterial bed

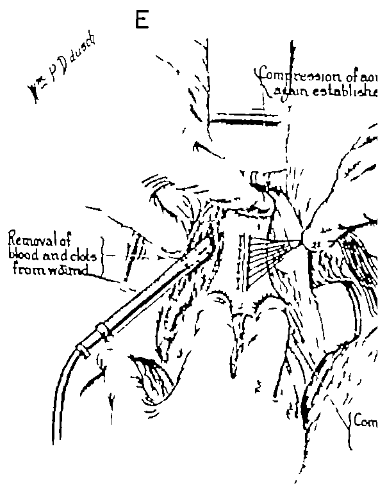
DISCUSSION—DR. FERDINAND F MCALLISTER I am in general accord with the principles outlined in this section, but have employed minor variations in technic Lower abdominal midline incisions have been found very helpful in exposure of the aorta and both iliacs. The midline position allows equally good exposure for either iliac, can be rapidly extended upward if need be, and is more quickly closed. I have not observed any greater tendency to postoperative hernia through this incision than through a paramedian muscle retracting incision.

I have felt that it is important to carefully encircle the iliac vessels with doubly looped umbilical tapes, distal to the area of obvious involvement with embolus before any manipulation of the involved area is attempted With the use of these tapes it may be possible to prevent any fragmentation and passage of clot more distally Whenever such occlusion is performed with the tapes, 2 to 3 mL of heparin solution should be injected into the vessels distal to the area of occlusion. As far as proximal occlusion of the aorta goes, above the level of the embolus I have felt more secure with complete encirclement of the aorta with a tape and the employment of a Rumel type tourniquet In some emboli which have been tackled after two to three days the clot is rather adherent and a good deal of manipulation may be required to loosen it I have not felt that finger control is adequate for this, and I do not believe that the careful use of thick cotton tapes fragments the intima excessively Again, whenever the aorta has been occluded proximally 2 to 3 ml of heparin solution should be injected proximal to the area of occlusion

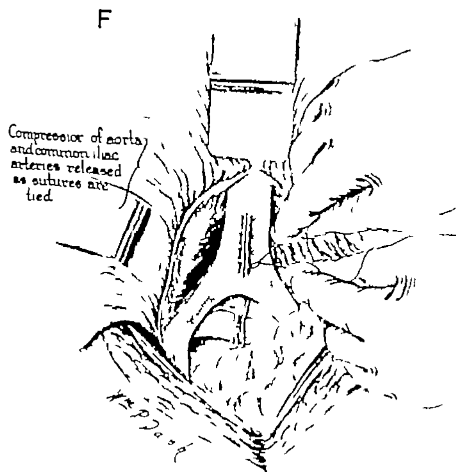
I have always felt that the best vascular closure was a simple over and over stitch of accurately placed 00000 arterial silk. I do not believe that the time factor here is as important as stressed by the author since the aorta has been occluded for some time anyway by the embolus. The entire lumen previously occupied by the embolus should be carefully and frequently and thoroughly flushed with heparin solution until the closure is complete. Once the closure is complete, the hemostatic tapes should be immediately released, and, unless drastic hemorrhage ensues through the wound, the vessel should never again be completely occluded, for this is sure to lead to clot formation. Care should be taken to control the proximal aorta digitally as the proximal tape is released in order to precipitate neither shock nor the reflexes which have been shown to lead ultimately to lower nephron nephrosis with renal shut down

Since additional distal emboli due to fragmentation of clot are not uncommon in such patients, two precautions should be taken before embarking on the performance of saddle embolectomies. First, the groins and thighs should be included in the prep and drape, so that if necessary the femoral arteries can be quickly exposed for the extraction of additional clots Second, a selection of plastic and firmly polished catheters should be available to insert into the distal iliac vessels if back bleeding is poor following removal of the main thrombus. Frequently a long complete slender thrombus can be extracted by the judicious use of such catheters and obviates the need for additional embolectomies at lower levels.

E


Compression of aor
again establishe
Removal of
blood and clots
from wound
Com

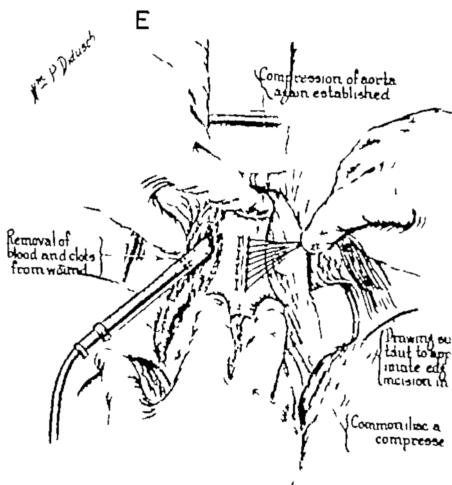
F


Compression of aorta
and common iliac
arteries released
as sutures are
tied

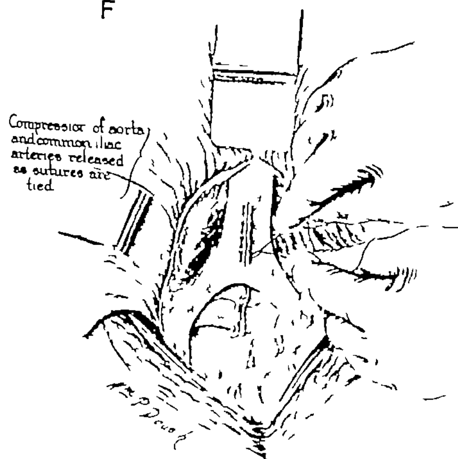
E. The thrombus is completely evacuated and the lumen of the aorta is momentarily occluded proximal to the incision either by the index finger (first assistant), as depicted, or by an anatomic tissue forceps (10 inches) as the strands of silk mattress sutures are drawn taut to close the opening in the aorta. The operative field is toileted by irrigation with warm sterile normal saline solution which is removed by suction siphonage.

F. The compression of the aorta and the common iliac arteries is released, and the last *of the everting mattress sutures of silk* (00000) closing the aortic incision is being tied. If sites of bleeding in the incised aorta should persist, hemostasis is obtained either by gentle compression on the suture line for several minutes using a sterile dry gauze sponge or by the insertion of additional simple interrupted silk (00000) sutures, dependent upon the severity of the bleeding. The incised portion of the posterior parietal peritoneum is not sutured. A layer closure of the abdominal incision is performed using interrupted sutures of 00 silk for the peritoneum and fascia and 000 silk for the skin. Drainage of the wound is not employed. Because of the high incidence of complications due to hemorrhage anticoagulant therapy postoperatively has been discontinued.

E

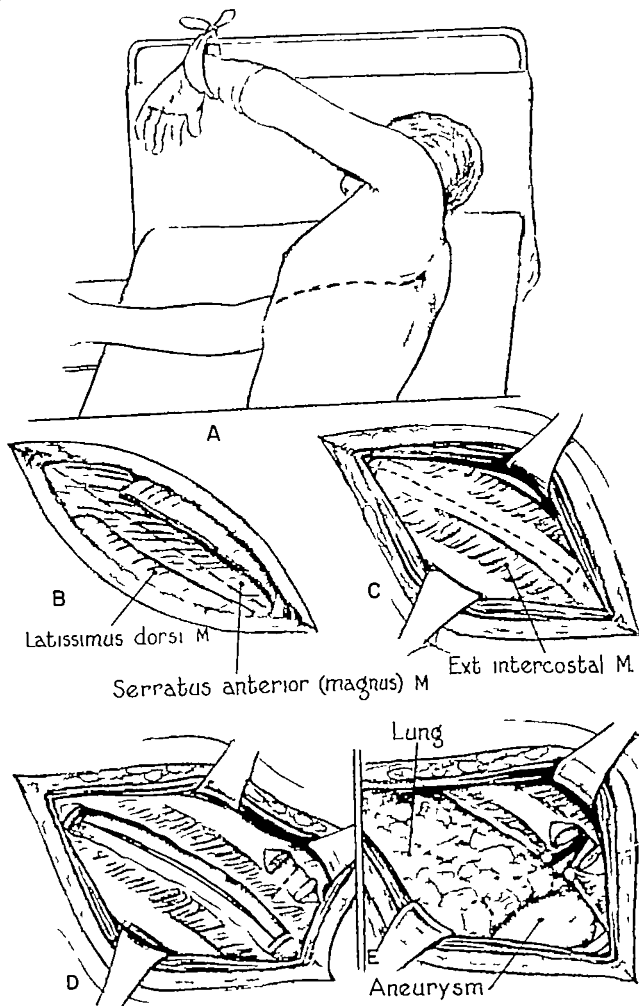

Compression of aorta again established
Removal of blood and clots from wound
Commoniliac a compresse

F


Compression of aorta and common iliac arteries released as sutures are tied

E. The thrombus is completely evacuated, and the lumen of the aorta is momentarily occluded proximal to the incision either by the index finger (first assistant) as depicted, or by an anatomic tissue forceps (10 inches) as the strands of silk mattress sutures are drawn taut to close the opening in the aorta. The operative field is toileted by irrigation with warm sterile normal saline solution which is removed by suction siphonage.

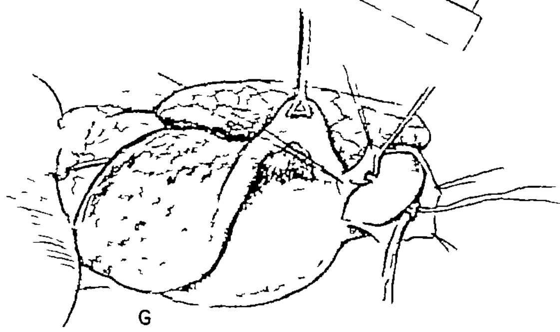
F. The compression of the aorta and the common iliac arteries is released, and the last of the everting mattress sutures of silk (00000) closing the aortic incision is being tied. If sites of bleeding in the incised aorta should persist, hemostasis is obtained either by gentle compression on the suture line for several minutes using a sterile dry gauze sponge or by the insertion of additional simple interrupted silk (00000) sutures, dependent upon the severity of the bleeding. The incised portion of the posterior parietal peritoneum is not sutured. A layer closure of the abdominal incision is performed using interrupted sutures of 00 silk for the peritoneum and fascia and 000 silk for the skin. Drainage of the wound is not employed. Because of the high incidence of complications due to hemorrhage, anticoagulant therapy postoperatively has been discontinued.

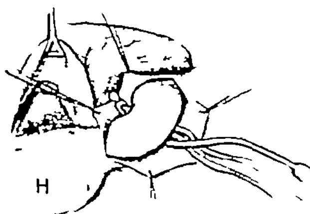

A
B
Latissimus dorsi M
Serratus anterior (magnus) M
C
Ext intercostal M
D
Lung
E
Aneurysm

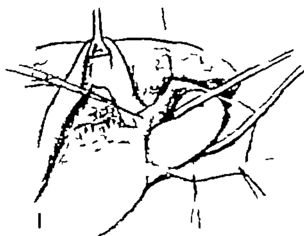
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Pericardium
Phrenic N
Atelectatic lower lobe left lung
Upper lobe
Arch of aorta
F
Aneurysm thoracic aorta


G


H


I

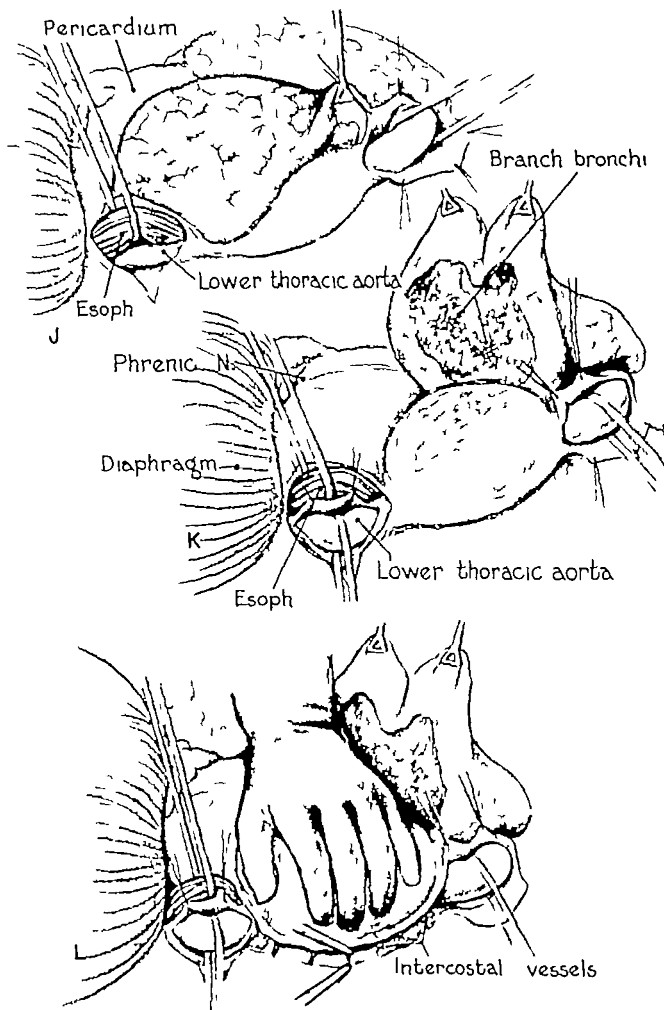
EXCISION OF AN ANEURYSM OF THE THORACIC AORTA AND THE INSERTION OF A PRESERVED HOMOLOGOUS AORTIC GRAFT

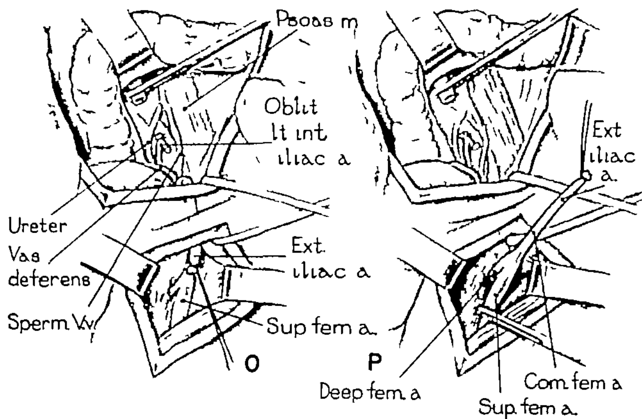
A. The patient is placed in the direct right lateral prone position The site of the left thoracotomy incision is depicted by the dotted line

B C. The skin incision is deepened through the underlying musculature of the lateral thoracic wall (B C) The H-shaped incision to be made in the periosteum of the sixth rib (C) is shown in dotted outline

D A long segment of the sixth rib and a small segment of the posterior portion of the fifth rib are resected subperiosteally The severance of the intervening intercostal muscle layers and their neurovascular bundle is indicated by the dotted line.

E. The intercostal muscle layers and the related neurovascular bundle are severed and ligated with suture ligatures of silk (00). The wound margins are retracted and a portion of the aneurysm which is partly covered by the overlying and adherent left lung is visible within the pleural cavity


Pericardium
Branch bronchi
Lower thoracic aorta
Esoph
J
Phrenic N.
Diaphragm
K
Lower thoracic aorta
Esoph
L
Intercostal vessels

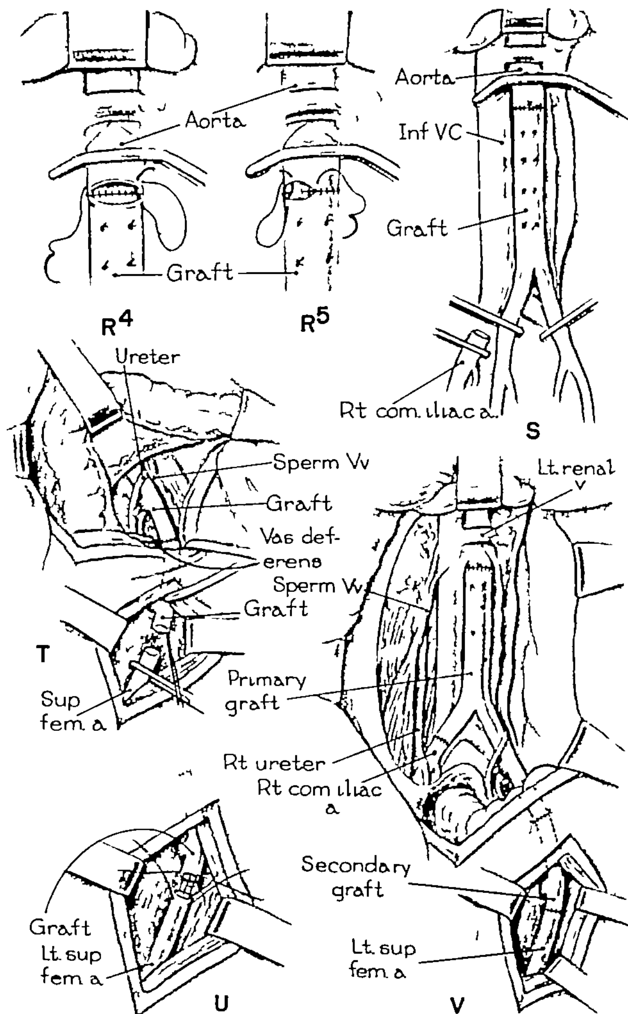


Aneurysm
Obliterated
com iliac a
Q
Rt com
iliac a
(patient)
Graft
R
R^1
Aorta
Graft
R^2
R^3
Aorta

J. An incision is made in the posterior mediastinal and parietal pleura distal to the aneurysm, and the lower end of the esophagus is shown encircled by a cotton tape. A segment of the distal portion of the thoracic aorta is also visible.

K. The distal segment of the thoracic aorta is similarly encircled by a cotton tape, and the adherent lobe of the left lung is dissected completely from the surface of the aneurysm. The lines of closure of the openings in the small stem bronchi, made during the dissection, are visible. In retrospect, this was a technical error which could have been easily avoided by not performing the dissection as illustrated. Instead, at the time of the resection of the aneurysm, a portion of its wall that was intimately adherent to the lung could have been tailored to form a "patch" graft and the occurrence of bronchial air leaks obviated. The same reasoning applies to the separation of the wall of the aneurysm from the segment of the esophagus to which it was adherent. The use of a "patch" graft is ideally suited as a prophylaxis to injury of the esophagus.

L. Preparatory to mobilizing the aneurysm, the incision in the posterior parietal pleura is extended along the whole length of the posterior border of the aneurysm. By gentle manual manipulation the aneurysm is displaced anteriorly to show its mobilization by serially clamping, severing, and ligating the related intercostal arteries.


Aorta
Graft
R4
Aorta
Graft
R5
Aorta
Inf VC
Graft
Rt com. iliac a.
S
Ureter
Sperm Vv
Graft
Vas deferens
Sperm Vv
Graft
T
Sup fem. a
Primary graft
Lt. renal v
Rt ureter
Rt com iliac a
Graft
Lt. sup fem a
U
Secondary graft
Lt. sup fem. a
V

O The left common iliac artery and the left external iliac artery are severed proximally and distally respectively to the internal iliac artery and the distal transected end of the external iliac artery is partially withdrawn beneath the inguinal ligament into the thigh The T shaped appearance formed by the ligated stumps of the common and external iliac arteries in relation to the obliterated internal iliac artery is visible.

P The withdrawal of the distal segment of the left external iliac artery beneath the inguinal ligament is completed, and the superficial femoral artery is cross-clamped with a straight Potts clamp

Q The obliterated left common iliac artery is severed just distal to the aortic bifurcation, and noncrushing clamps (Potts) are applied to the right common iliac artery and to the aorta proximal to the uppermost aneurysmal dilatation The dotted lines indicate the respective sites for transection of the aorta proximally and the right common iliac artery distally

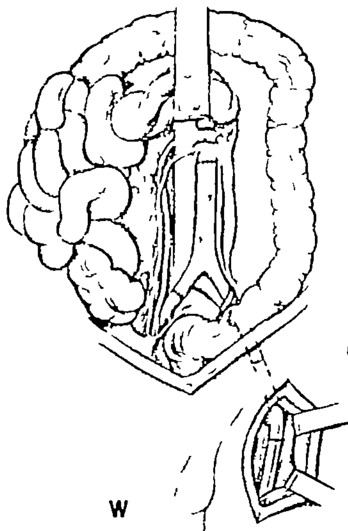
R. The common iliac arterial branches of the preserved homologous bifurcation graft are clamped (Potts clamps) and elevated to show the initiation of the anastomosis between the aorta and the homologous graft by the insertion of two silk (00000) sutures in the midline posteriorly

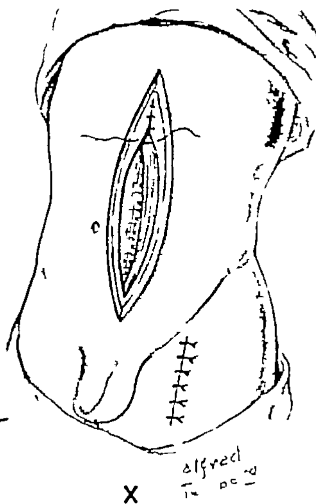
R^1 R^2 R^3 The sutures posteriorly are tied, and one of the sutures proceeds to the patient's left (R^1) and the other to the patient's right (R^2) to complete the insertion of the posterior layer of the anastomosis (R). The insertion of each suture is begun on the graft side so that the needle, when inserted on the host aortic side impinges the intima plaques which are usually present against the underlying coats of the aorta.

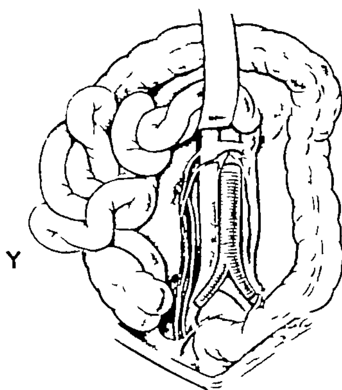
Discussion—Dr De Bakey (cont)

segment of the graft to the right iliac artery After completing this latter anastomosis, the occluding clamp on the right iliac artery would be removed and an effort made to obtain retrograde flushing of the vessel to remove any debris or clots that may have accumulated distal to the clamp After good retrograde blood flow was assured, an occluding clamp would be applied to the right iliac segment of the graft just distal to the bifurcation and the aortic clamp released for a few seconds to flush out the aorta through the graft and the remaining open end of the left iliac segment of the graft This assures removal of any debris and clots that may have accumulated in the blind segment of the aorta proximal to the clamp Following these maneuvers, the occluding clamp on the right iliac segment of the graft is removed and applied to the left iliac segment of the graft just distal to the bifurcation The aortic clamp is then slowly released, permitting circulation to be restored through the graft and into the right lower extremity

Attention may now be directed toward anastomosis of the left iliac segment of the graft. In this case, since the left common iliac artery was occluded, it is necessary to extend the left iliac segment of the graft beyond this level Under these circumstances, our experience has led us to use the bypass principle. The occluded segment of the left iliac artery is allowed to remain undisturbed, and, instead of resecting the common femoral artery we would probably have performed an endarterectomy in this region and attached the graft as an end-to-side anastomosis This has the advantage of being a simpler and less time-consuming procedure and has proved effective in our experience. Significantly we have never encountered gangrene as a complication of this operation


W

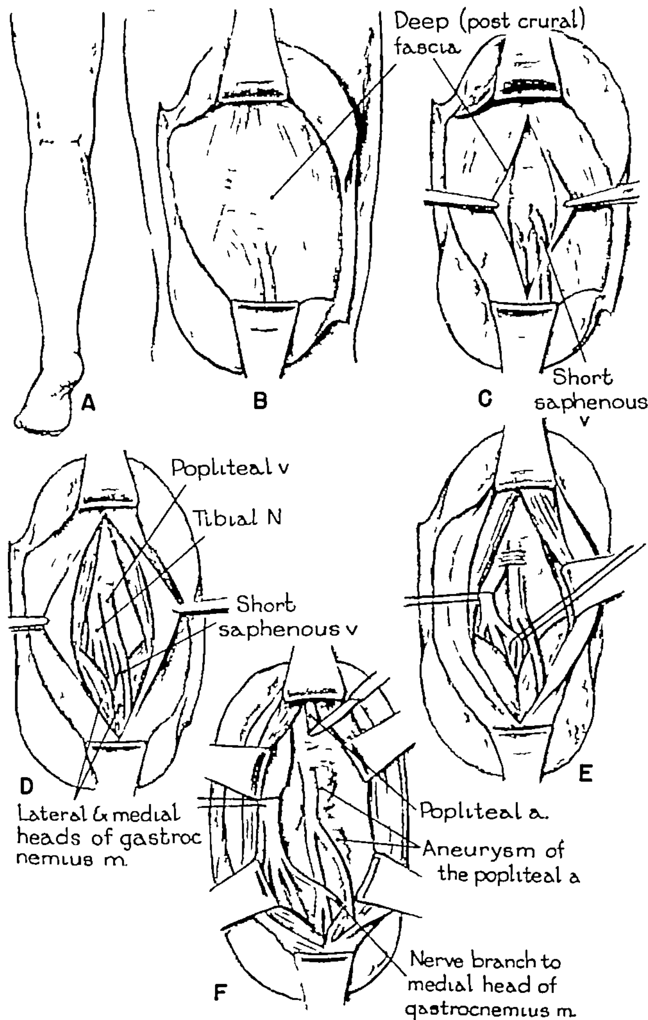

X


Y

R[4] R[5] S. The graft is displaced downward, and the insertion of the anterior layer of the anastomosis is continued from either side (R R) to meet in the midline anteriorly where the sutures are tied together (S). As previously stated, the insertion of the needles on the host aortic side anteriorly is again in such a manner as to impinge the intima coat against the underlying coats of the aorta.

T The external iliac segment of the aortic bifurcation graft was too short to reach to the level of the superficial femoral artery Accordingly the unused portion of the right common iliac artery of the graft and its bifurcation was used on the left side to gain the necessary length to complete the anastomosis with the superficial femoral artery The substitute graft segment was inserted in a reversed direction, and its terminal external iliac segment was anastomosed to the terminal portion of the left external iliac artery The terminal segment of the common iliac artery (right) of the substitute graft segment is in readiness to be anastomosed to the superficial femoral artery

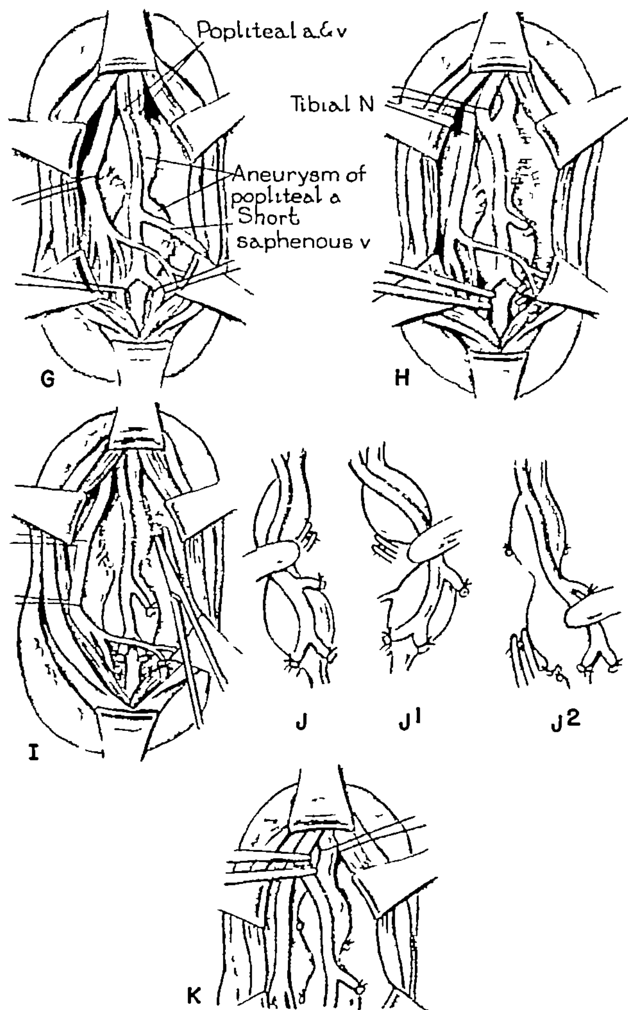
U V The three cardinal guy sutures of silk between the common iliac artery segment and the superficial femoral artery are inserted (U), and the end-to-end anastomosis in the proximal portion of the left side is completed (V). In this particular patient, anastomosis of the graft with the internal iliac arteries was not required. However in the excision of aneurysms of the abdominal aorta in which transection distal to the common iliac arteries is done, anastomosis of the internal iliac arteries, if patent, to the graft is practiced. In one patient in whom ligation rather than anastomosis of the internal iliac arteries was done, two large areas of tissue necrosis of the tissues deep within the buttocks with secondary skin necrosis occurred. Furthermore, in some patients, compromise of the blood supply to a segment of the colon may result from failure to anastomose the graft with the internal iliac arteries


Deep (post crural) fascia
A
B
C
Short saphenous v
Popliteal v
Tibial N
Short saphenous v
D
E
Lateral & medial heads of gastrocnemius m.
Popliteal a.
Aneurysm of the popliteal a
F
Nerve branch to medial head of gastrocnemius m.

W X. The insertion of the preserved homologous bifurcation graft and the substitute extension graft is completed. The anastomosis on the right side is to the common iliac artery and on the left to the superficial femoral artery in the thigh (W). The closure of the incision in the proximal portion of the left thigh is completed and the abdominal wound is being closed using both interrupted mattress sutures and simple interrupted sutures of 00 silk for the peritoneum and interrupted sutures of 00 silk for the anterior rectus sheath (X). The skin incision is subsequently closed with interrupted sutures of 00 silk.

Y The restoration of continuity of the abdominal aorta by the insertion of a woven dacron cloth prosthesis is depicted. Woven dacron (or teflon) grafts are now used routinely The use of homologous aortic grafts as illustrated (R V) is no longer practiced and is considered only of historic interest. However the suture technic employed, simple over and over sutures, remains the one of choice

The patient, a 55 year-old white man, was admitted to the hospital with the history that, during the preceding year pain in the left leg on walking, relieved by rest, was noted. The symptoms persisted, and, during the two months prior to admission to the hospital, pain in the left hip and the low back was observed Examination at this time demonstrated a palpable pulsatile mass in the lower abdomen and the absence of pulsations in the left femoral artery The pulsations in the right femoral artery were normal A diagnosis of an aneurysm of the abdominal aorta with segmental occlusion of either or both the left common and external iliac artery was made. At operation, multiple (four) relatively small aneurysms of the abdominal aorta were present in conjunction with atherosclerotic obliteration of the left common iliac, the internal iliac, the external iliac, and the common and profunda femoral arteries. The local pathologic findings in the aorta and its peripheral arterial branches on the left side were consistent with the diagnosis of juvenile arteriosclerosis (Leriche). The pathologic findings present accounted for the relative ease with which the involved segment of the abdominal aorta was freed from the adjacent inferior vena cava Following the insertion of the preserved homologous aortic graft as depicted in the illustrations, an excellent arterial pulsation was restored in the left superficial femoral artery The subsequent postoperative course was without incident, and the patient was discharged from the hospital in satisfactory condition on the 16th day after operation


Popliteal a.&v
Tibial N
Aneurysm of
popliteal a
Short
saphenous v
G
H
I
J
J1
J2
K

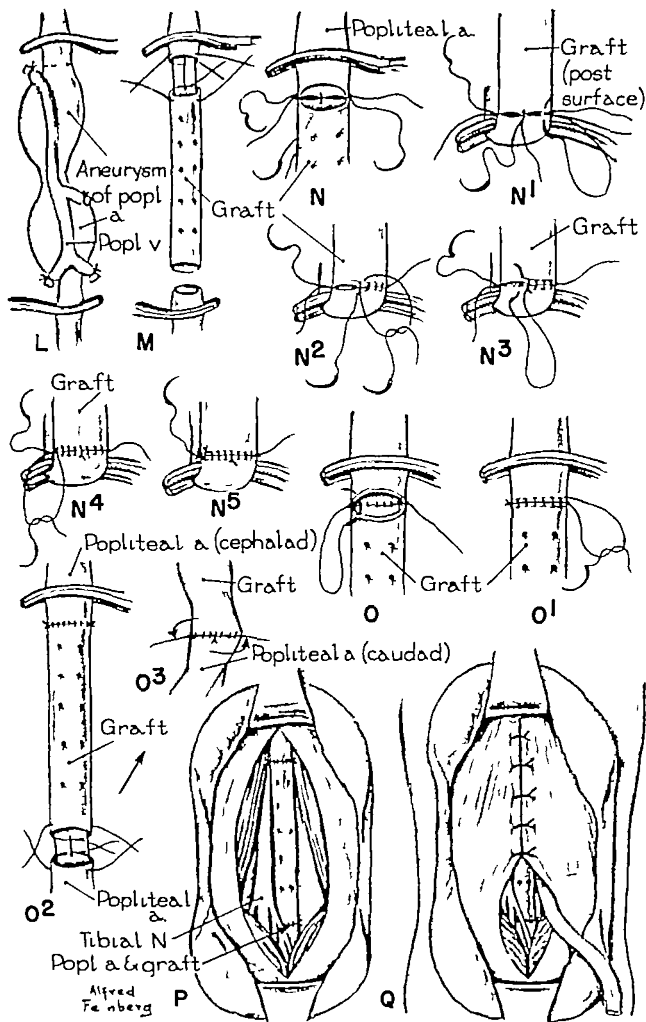
EXCISION OF AN ANEURYSM OF THE POPLITEAL ARTERY AND THE INSERTION OF AN ALCOHOL (70 PER CENT) PRESERVED HOMOLOGOUS AORTIC (THORACIC) GRAFT

A. The incision employed, depicted in dotted outline is preferred to one of the midline longitudinal type.

B. The mobilized flaps of skin and subcutaneous fatty tissue are retracted to expose the posterior crural fascia and the underlying muscles. The perforation of the crural fascia by the short saphenous vein (saphena parva) is visible.

C D E. The incised margins of the linear incision in the posterior crural fascia are retracted in clamps (C), and, by scissor dissection in the underlying tissue, the popliteal vein and the entrance of its tributary the short saphenous vein are demonstrable A portion of the tibial nerve and its branches, as well as portions of the surrounding musculature, are also delineated (D E)

F The dissection is continued within the deeper tissue and the superior pole of the popliteal artery and the outline of its "dumbbell" aneurysm immediately distal are visible A greater length of the tibial nerve is now exposed, and its branch to the medial head of the gastrocnemius muscle may be seen arched across the lower portion of the popliteal vein.


Popliteal a.
Graft
(post
surface)
Aneurysm
of popl
a
Popl v
Graft
N
N1
L
M
Graft
N2
N3
Graft
N4
N5
Popliteal a (cephalad)
Graft
Graft
O
O1
O3
Popliteal a (caudad)
Graft
O2
Popliteal
a.
Tibial N
Popl a & graft
Alfred
Feinberg
P
Q

G H. The operative field is more widely exposed and the bifurcation of the branch of the tibial nerve to the medial head of the gastrocnemius muscle may be seen. The popliteal vein, inextricably adherent to the posterior wall of the aneurysm, was removed with the specimen. Accordingly its lowermost tributaries and the short saphenous tributary were doubly clamped, severed, and ligated (H) In doing this care was observed to avoid injury to the overlying nerve branch to the gastrocnemius muscle.

I Scissor dissection is continued to mobilize completely the "dumbbell" aneurysm from its surrounding structures

J J1 J2 In mobilizing the aneurysm, it is deflected first to one side (J) and then the other (J) to expose the arterial branches which are doubly clamped severed, and ligated (00 silk) The majority of the arterial branches were in the lower aneurysmal dilatation of the popliteal artery (J2).

K. The aneurysm is completely mobilized, and its superior pole is encircled with a ligature of silk (0) The cephalad portion of the popliteal vein is doubly clamped prior to its severance and ligation (00 silk)

DISCUSSION—DR. ROBERT R LINTON Popliteal aneurysms, whether of luetic, arteriosclerotic, or traumatic origin, should be excised as described and illustrated in the text because they are a risk to both limb and life if not treated Secondary thrombosis eventually occurs if they are left in place with resulting gangrene of the leg necessitating amputation in the majority of cases This can be prevented in all cases by resection of the aneurysm with the insertion of some type of graft to restore arterial continuity It has been found possible to excise these aneurysms safely prior to grafting procedures, by first protecting the limb by a preliminary lumbar sympathetic ganglionectomy

In more recent years, it has been possible, with the advance in the technic of arterial grafting procedures, to restore arterial continuity in these cases by the implantation of some type of graft. By this newer method, it has not been necessary to perform the lumbar sympathectomy in the majority of cases In addition, the intermittent claudication which inevitably followed the resection of the aneurysm has been prevented by the restoration of arterial continuity so that, in general, the method as described and illustrated is to be highly recommended.

It is believed that some of the details of the technic, as shown in the illustrations, can be improved upon in the performance of this procedure. In addition, the type of homograft that is recommended is open to some question The type of incision used to expose a popliteal aneurysm has never been completely agreed upon. The S-type that is shown in Plate 137A is recommended by some, but it is the opinion of many vascular surgeons that the best incision for operations on major blood vessels is an incision which parallels the course of the blood vessel. Therefore, if the S-type of incision is to be used, it would seem better if the upper extension of it were on the inner side of the thigh rather than on the outer as is shown, since that is the direction and course of the popliteal and femoral arteries. My preference, on the other hand, is a longitudinal incision without the S-type of configuration. This has been used in several hundreds of cases and has not been the cause of any contracture difficulty providing the incision is resutured properly and the limb is placed in a posterior splint for a week after the operative procedure.

Retraction of the posterior tibial and peroneal nerves, as shown in Plate 137E, can be less traumatic if a thin piece of Penrose drain is used instead of the ligatures as shown. It is frequently necessary especially with large aneurysms, to divide the nerve supply to either head of the gastrocnemius muscle If such is the case there should be no hesitancy in doing this because it results in little, if any incapacity Rarely is it necessary to sacrifice the nerve supply to both heads of this muscle

The popliteal vein is beautifully shown in the Plate 138G H and I, and if possible, preservation and utilization of this vein as an autogenous venous graft to replace the portion of popliteal artery that has to be resected is recommended. In some instances, this is not possible because the vein is so firmly adherent to the aneurysm it cannot be dissected free without injuring it. When this can be accomplished, however the popliteal vein is believed to make the most satisfactory reconstruction graft that can be found. In other instances, it is recommended that the saphenous vein be utilized if it is found to be of large enough caliber Autogenous blood vessels are found to serve much more satisfactorily than any other type of arterial replacement, whether it be homologous venous or arterial grafts, or artificial prostheses.

In reviewing the illustrations, there is one very important step in the procedure which is not shown until Plate 139L. *This is the application of an occlusive* clamp to the popliteal artery distal to the aneurysm. It is recommended that one should be applied before any dissection of the aneurysm is commenced because, if it is not, there is great danger of breaking off portions of an intraaneurysmal clot and causing embolic occlusions of the arteries distal to the aneurysm with resultant serious impairment of the circulation to the lower leg In my opinion the best type of clamp is a small "bulldog" one *it should be applied to the popliteal artery just distal* to the aneurysm before carrying out any extensive *dissection elsewhere.*

There are various technics of implanting a venous autograft, an arterial homograft, or an artificial synthetic prosthesis. The method illustrated in the plates is one that has been discarded because with the use of a running suture as demonstrated, stenosis inevitably results at the site of the anastomosis. Instead of the method as depicted, it is recommended *that longitudinal slits be made in the host artery and* the graft, which permit a much more easily accomplished end-to-end anastomosis without stenosis even with a running over and over suture. This method of anastomosis also permits one to utilize a blood vessel of smaller caliber than one can use by the end-to-end technic as shown in the illustrations.

The utilization of aortic grafts preserved in alcohol is open to some question. The chief advantage is the availability of them. In *the majority of cases,* it is believed that a thoracic aorta is much too large in caliber to utilize satisfactorily for the replacement of a peripheral artery such as the popliteal This may be possible as the result of the sclerosing and shrinking action of the alcohol on the aortic graft.

Drainage of the operative field is of doubtful value, and especially so if one is utilizing a homograft, because of the danger of infection It is recommended that extreme care should be exercised to obtain complete hemostasis so that drainage will not be necessary After closure of the incision and the application of a sterile gauze dressing, a posterior splint of either wood or plaster should be applied to keep the knee in extension and so prevent a contracture in the scar It is recommended that it should not be removed until the fifth postoperative day

L. The superior and inferior poles of the "dumbbell" aneurysm are clamped (Potts clamps) prior to transection (dotted lines) and removal of the aneurysm with the at tached popliteal vein

M. In this patient, the diameters of the lower portion of the femoral artery and the distal segment of the popliteal artery were ex tremely large and required the use of the thoracic segment of an alcohol (70 per cent) preserved homologous aortic graft to obtain a proper fit The three cardinal guy su tures (00000 arterial silk) are inserted, one posteriorly and one at either lateral angle, but not tied.

N N^1 N^2 N^3 N^4 N^5 The guy sutures are tied and the suture strands are left long (N) The lower end of the graft is elevated to show the start of the posterior layer of the anastomosis (N) One of the lateral angle sutures is inserted as a continuous over and over suture to the midline poste riorly where it is tied to the free end of the posterior cardinal guy suture (N^2) The needle attached strand of the posterior car dinal guy suture is similarly continued as an over and over suture (N^3) and tied to the free end of the remaining lateral angle cardinal guy suture (N N^4)

O O^1 The aortic (thoracic) graft segment is turned downward to show the insertion of the sutures forming the anterior layer of the anastomosis. The needle attached strand of one of the lateral angle cardinal guy sutures (N^5) is continued anteriorly as a continuous over and over suture (O) and tied to the free end of the opposing lateral angle guy suture (O) The needle is inserted from the "inside out" on the host popliteal ar tery to impinge the calcific plaques which are frequently present in the intima against the underlying coats of the vessel.

O^2 The proximal anastomosis is completed, and the three cardinal guy sutures are sim ilarly inserted distally but not tied

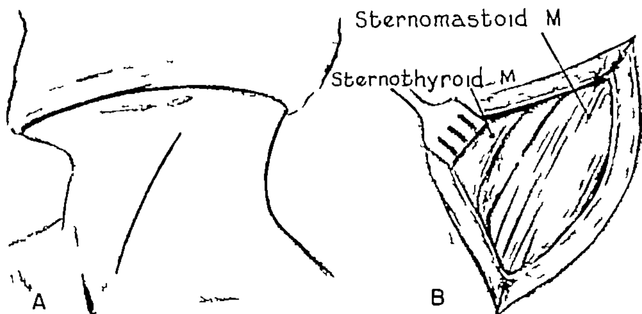
O^3 The use of the free ends of the lateral angle cardinal guy sutures to rotate the graft and arterial segments for the inser tion of the posterior layer of sutures, as previously depicted, is shown.

P The insertion of the thoracic segment of the alcohol (70 per cent) preserved homologous graft to restore continuity of the popliteal artery is completed, and its relation to the surrounding structures is visible.

Q. A rubber tissue drain is inserted into the popliteal fossa, and the incision in the posterior crural fascia is closed with inter rupted sutures of 000 silk. The closure of the skin incision and the application of a sterile gauze compression dressing com plete the operation

DISCUSSION—DR. ORMAND C. JULIAN The very marked tendency for thrombosis to occur in a popliteal aneurysm provides the absolute indication for their removal as soon as the diagnosis is made In spite of their location, which subjects them to a peculiarly constant movement as the knee flexes and extends, they rarely rupture. Obstruction to arterial flow into the leg associated with aneurysm also results from occlusion of the popliteal artery just beyond the aneurysm usually very close to the popliteal artery bifurcation In this instance, the arterial pulses are absent at the ankle while at the same time the aneurysm continues to exhibit expansile pulsation. Whether this occlusion is entirely the result of an arteriosclerotic change in the popliteal artery beyond the aneurysm, or due primarily to kinking of the vessel in this area associated with elongation of the aneurysmal segment of the popliteal artery is not clear However the blood supply to the leg may remain adequate for survival by way of collaterals which probably arise proximal to the aneurysm rather than from it. Actually a complete thrombosis of a popliteal aneurysm is not always associated with a severe degree of acute ischemia of the leg.

The additional fact that popliteal aneurysms may be resected without loss of the extremity even if continuity is not restored by a graft, if (1) a lumbar sympathectomy is done in preparation and (2) maximum care is taken to avoid damage to collaterals in the knee area, has led us to vary the technic of popliteal artery aneurysm resection This variation, which will be mentioned in the discussion of specific elements of the illustrated oper



Traumatic aneurysm
left common carotid A

C

D

Vagus N

DISCUSSION—DR. JULIAN (cont.)

ation, consists of opening and thromboendarterectomizing the aneurysmal sac after obtaining close proximal and distal control of the afferent and efferent popliteal segments. Branches of the vessel which arise in the aneurysmal portion may then be tied or sutured from within the sac, thereby avoiding in the greatest degree possible damage to collateral vessels. Then if re-establishment of vascular continuity proves impossible or insecure, as is sometimes the case if occlusion has already developed, ischemic necrosis of the extremity is avoided. In patients having prior occlusion either by thrombosis of the aneurysm or arteriosclerotic obstruction of the vessel distal to the aneurysm, a lumbar sympathectomy is done at some time in relation to the operation for aneurysm.

The selection of a segment of the patient's saphenous vein or one of woven dacron tubing for restoring circulation is optimum. The defect resulting from removal of the popliteal aneurysm is usually not very long and the graft used to fill it does not really cross the active flexion area of the knee. Since the lesser saphenous vein is not to be depended upon for size and muscularity and the long saphenous vein may be difficult to obtain in the semi-prone position most often used, a Dacron prosthesis is frequently our choice.

A Z-shaped incision, such as that illustrated in Figure A, is most often used except that the proximal limb would seem better placed on the medial side of the thigh where an extension even further proximally will allow for higher control of the popliteal artery if the aneurysm is an extensive one. Indeed, proximal control in the thigh at the level of the adductor hiatus is sometimes convenient in very large aneurysms. Another variation which we have found valuable has been to carry the distal limb of the incision downward in the midline of the calf which obviates the need for any elevation of a distal flap as shown in Figure B.

The odd dumbbell shape of the popliteal aneurysm illustrated has been present in several cases in our series. It seems to be produced by an especially firm area of the fascia of the popliteal fossa which crosses the waist of the lesion. A careful definition and dissection of the nerve and its branches is essential. However it is often difficult to free the displaced and compressed popliteal vein from the aneurysm and this is not essential at this stage if the aneurysm is to be opened and cleared out after clamping the popliteal artery above and below it. It is believed that preservation of the popliteal vein is worthwhile in preventing the postoperative edema of the leg which occasionally otherwise occurs.

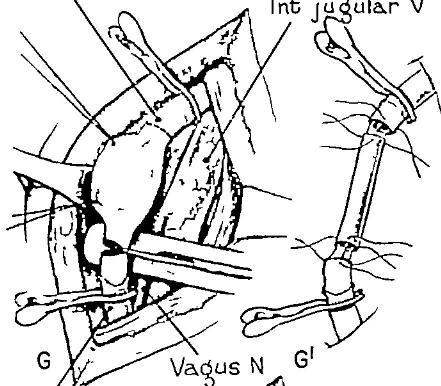
In small aneurysms, the dissection and removal can easily follow the steps illustrated in Figures G through J_2. The mobility of a small lesion is such that arterial branches originating from it can be controlled close to the wall but at the same time the compression of the popliteal vein is usually not so great but what it can be freed and preserved. In large aneurysms much time may be spent without real advantage in freeing the wall of the aneurysm from outside, and if the sac is instead opened and evacuated much of the wall may be then removed far more easily, arterial branches controlled more quickly and the vein which can assume its normal size with the compressing force relieved be dissected without damage from the loose aneurysm wall.

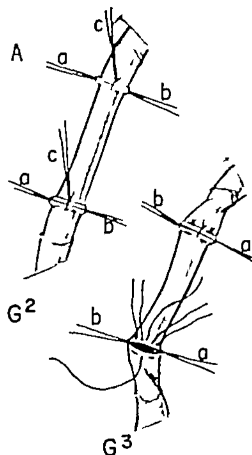
Whether the aneurysm is removed intact or after incision and thromboendarterectomy the artery proximally and distally is transected and the stage indicated in Figure M reached. The technic used in doing each of the two anastomoses is subject to great variation. They are almost always carried out using continuous sutures, interrupted as shown at two points in the circumference. The first anastomosis is more easily accomplished because the other end of the graft is free and, therefore, it may be advantageous to do the distal one before the proximal. This is because the transection is often quite close to the popliteal artery bifurcation, or because thromboendarterectomy may have been required at this point to fashion a proper lumen through which good backflow occurs in patients with distal occlusive disease.

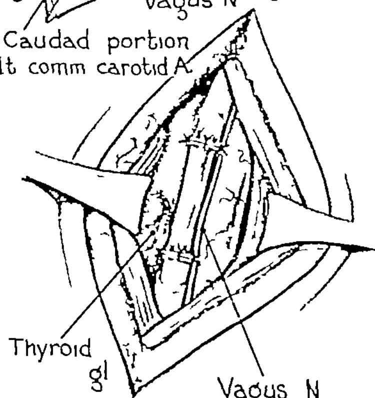
Arteriosclerotic changes in the patient's vessel may make it unwise to rotate it in constructing the posterior row of the second anastomosis, as shown in Figure O_1, whether this be at the proximal or the distal end. An alternative to rotation is to place the holding sutures at dorsal and ventral points rather than at lateral points.

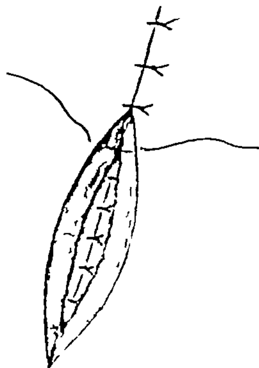
Two additional points deserve mention as maneuvers designed to prevent thrombotic or embolic occlusion of the distal arteries during the operation. One concerns early clamping of the efferent popliteal artery avoiding firm retraction of the aneurysm before this is done. The obvious purpose is to prevent downward displacement of some broken off piece of the mural thrombus that these aneurysms almost always contain. The second point concerns the use of heparin during surgery. This is administered at the time that circulation through the aneurysm into the leg is interrupted by clamping. It may be given as a single systemic dose of 0.25 to 0.5 mg. per kilogram, or injected in dilute solution into the distal popliteal arterial lumen which is opened early for this purpose.

Even with careful hemostasis, the use of a soft drain led from beneath the deep fascia through the skin wound is certainly desirable. It should, however, be removed in four to six hours to minimize the slight possibility that it might permit contamination of the graft.


Cephalad portion lt comm carotid A
Int jugular V
Vagus N
G
G'
Caudad portion
lt comm carotid A


c
a
b
c
a
b
b
a
G2
b
a
G3


Thyroid
gl
Vagus N
H


I

EXCISION OF AN ANEURYSM OF THE COMMON CAROTID ARTERY AND THE INSERTION OF AN AUTOGENOUS VEIN GRAFT

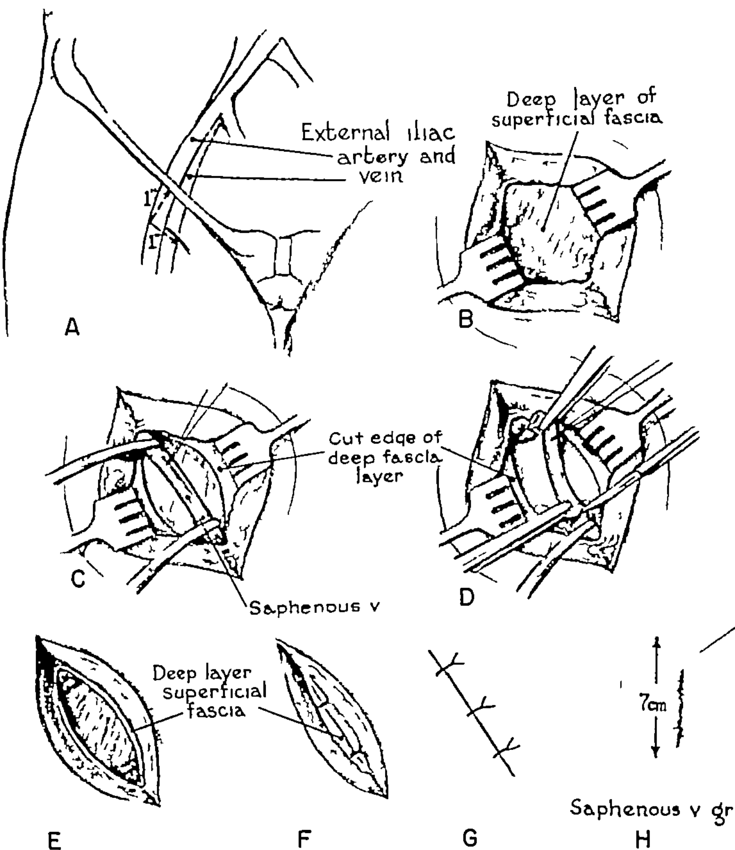
A. The oblique cervical incision paralleling the anterior border of the left sternomastoid muscle is indicated by the solid line.

B. The incision is deepened through the subcutaneous fatty tissue the platysma muscle and the anterior layer of the deep cervical fascia to expose portions of the sternothyroid and sternomastoid muscles.

C. The muscles are retracted and the summit of the traumatic aneurysm of the left common carotid artery is visible beneath the retracted margin of the sternomastoid muscle.

D The aneurysm and its collateral arterial branches are mobilized from the surrounding tissues by a combination of sharp and blunt dissection The common carotid artery both cephalad and caudad to the aneurysm, is encircled by cotton tapes for traction and, if necessary for temporary mechanical occlusion of the arterial lumen Guy sutures of silk (000) for traction are also inserted in the wall of the aneurysm.

E, F The collateral arterial branches are ligated and severed, and mobilization of the aneurysm is continued by scalpel dissection The adherence of the aneurysm to the internal jugular vein is visible


External iliac
artery and
vein
1"
1"
A
Deep layer of
superficial fascia
B
Cut edge of
deep fascia
layer
C
Saphenous v
D
Deep layer
superficial
fascia
E
F
G
7cm
Saphenous v gr
H

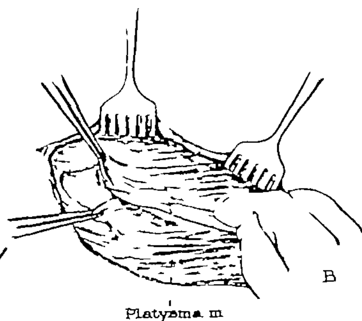
G The mobilization of the aneurysm and portions of the common carotid artery both cephalad and caudad, is completed The common carotid artery is occluded by Potts serrafine or "bull dog" clamps on either side of the aneurysm preparatory to its excision. A cuff of the adventitia layer of the artery is removed at each site of election for its transection This maneuver is more readily accomplished with the artery in continuity as depicted. The carotid artery caudad is being transected with a scalpel over an underlying sterile tongue depressor The site of arterial transection cephalad is indicated by the dotted line

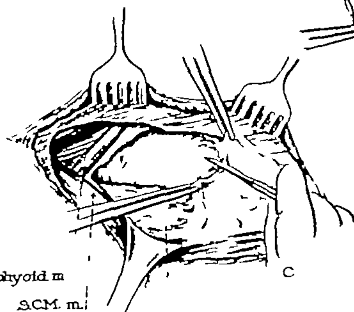
G^1, G^2 G^3 The excision of the aneurysm is completed, and the free graft of saphenous vein which is reversed (cephalad portion is caudad), is aligned between the transected ends of the common carotid artery by three equidistantly placed cardinal guy sutures (00000 silk), which are inserted but not tied (G) The guy sutures are tied (G^2), and the long strands are used for traction to facilitate the rotation of both the graft and the transected ends of the carotid artery for the insertion of the silk (00000) sutures posteriorly (G^3)

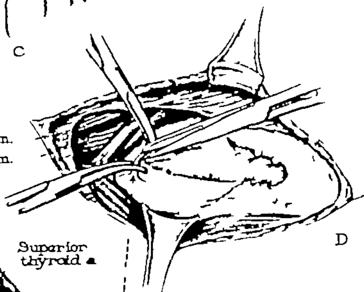
H. The excision of the traumatic aneurysm of the left common carotid artery and the insertion of the reversed free graft of the great saphenous vein are completed The relation of the graft to the surrounding structures is visible.

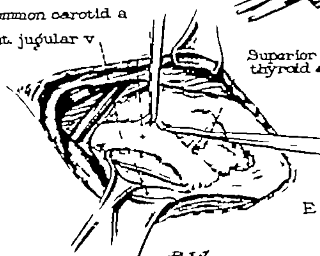
I. The anterior layer of the deep cervical fascia and then the skin are closed with interrupted sutures of 000 silk.


A


B
Platysma m


C
Omohyoid m
S.C.M. m.
Carotid sheath
Sternohyoid m.
Sternothyroid m.


D
Tributary of int jugular v


Common carotid a
Int. jugular v
Superior thyroid a
E

A. The incision for the removal of a free graft of the great saphenous vein is shown by the solid line. The center of the incision is located at a position 1 inch below the inguinal ligament and 1 inch medial to the femoral arterial pulsation. This has proved an excellent site for the exposure of the cephalic portion of the saphenous vein.

B. The skin incision is deepened to expose the deep layer of the subcutaneous fascia beneath which the saphenous vein is located.

C. The deep layer of the subcutaneous fascia is incised, and the saphenous vein is isolated from the surrounding fatty areolar tissue A guy suture of silk (00000) is inserted in the adventitia coat of the saphenous vein as a landmark for its proximal level of transection. The vein is doubly clamped The site for transection of the intervening segment is indicated by dotted lines.

D The resection of the segment of vein to be used as a free autogenous graft is being completed.

E, F G The transected ends of the saphenous vein are occluded proximally and distally with ligatures of 000 silk (E) and a layer closure of the wound is performed, using interrupted sutures of 000 silk (F G)

H. The length of free graft of saphenous vein obtained is shown. Prior to its insertion the vein graft is washed thoroughly in a heparin–saline solution (100 mg of heparin and 250 ml. of normal saline solution).

It should be emphasized that the cephalic portion of the great saphenous vein, because of the comparable diameter of its lumen, is an ideal donor for restoration of continuity of the common carotid artery

DISCUSSION—DR. HENRY T BAHNSON Aneurysms of the carotid artery are not common but in some instances will require treatment because of the danger of thrombosis or embolism from the lesion and a rare danger of rupture.

I would not consider the branches shown arising from the aneurysm as collateral branches, as there is no reason for collateral circulation in a simple arterial aneurysm. Indeed, one wonders *whether these actually arose from the aneurysm* itself as, there are normally no branches from the common carotid Sometimes vessels in the adjacent tissue become adherent to such an aneurysm but can be dissected off without actually entering the lumen.

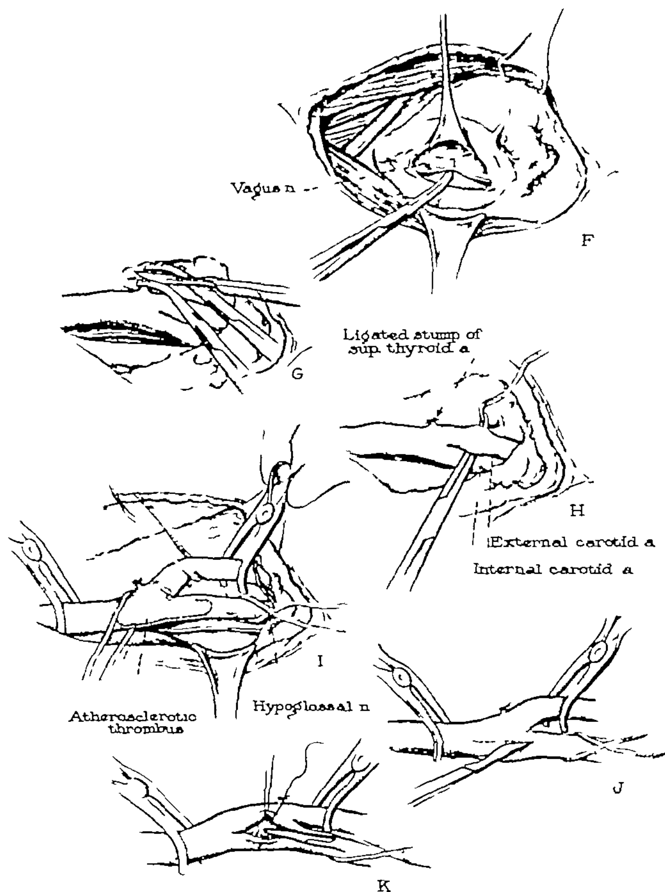
Inasmuch as both the common carotid below and the internal carotid above have no branches for some distance heparin probably should be instilled both proximally and distally to avoid clotting in the blind segment when the vessel is occluded.

The type of suture one uses is largely a matter of personal preference My own is for an everting mattress suture, usually continuous, or an over-and-over continuous suture. The latter is particularly useful when duration of occlusion is important and one must expedite the anastomosis. In any instance small size suture material should be used, and this is perhaps more important than the exact way of placing it.

In many instances sufficient mobilization of the carotid arteries can be obtained so that anastomosis might be done without a graft. If a graft is required, the saphenous vein is believed preferable. The graft should be treated as a fragile bit of living tissue and, hence, handled gently grasping only adventitia with forceps if it must be grasped. I would question the artist's illustration of the saphenous vein as I think it runs in a more vertical direction than shown *

With a satisfactory anastomosis and lumen, one normally would not need heparin or other anticoagulants in the postoperative period.

Lower down, yes but at this level the obliquity of the saphenous vein as depicted is believed characteristic (J L M)


Vagus n
F
G
Ligated stump of
sup. thyroid a
H
External carotid a
Internal carotid a
I
Atherosclerotic
thrombus
Hypoglossal n
J
K

CAROTID THROMBOENDARTERECTOMY

A. The patient is placed in the supine position, and the head is rotated to the right. The oblique cervical incision, paralleling the anterior border of the sternomastoid muscle, is indicated by the broken line.

Although local anesthesia is recommended by many for this operation, general anesthesia is preferred. Since these patients are frequently restless and uncooperative, the admitted advantage of having the patient awake to detect the signs of cerebral ischemia on occlusion of the common carotid artery is not infrequently offset by his restlessness.

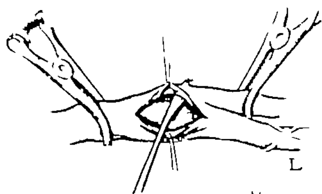
B. The platysma muscle layer is incised, and a portion of the underlying anterior or investing layer of the deep cervical fascia is visible. An unusually wide exposure of the platysma muscle, the fibers of which are accentuated, is shown.

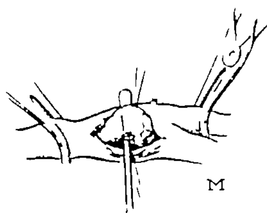
C. The anterior layer of the deep cervical fascia is incised, and the sternomastoid muscle is retracted posteriorly to expose the dissection of the fascia and fibroareolar tissue layers that overlie the carotid sheath. In the lower part of the wound, the inferior belly of the omohyoid muscle may be seen lying on its "fascial carpet," the middle layer (pre-thyroid) of the deep cervical fascia.

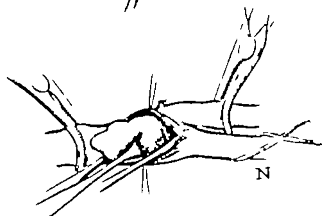
D. The carotid sheath is opened and a tributary of the internal jugular vein is being severed between clamps.

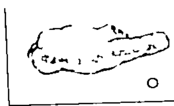
E. The mobilized segment of the internal jugular vein is retracted posteriorly and the adventitia of the common carotid artery is removed by scalpel dissection. The vagus nerve is visible between and deep to the vein and artery. The superior thyroid artery, which usually is the first branch of the external carotid artery, is also visible. In this patient it arose from the common carotid artery just proximal to its bifurcation.

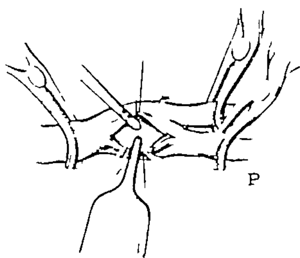
Plate 146

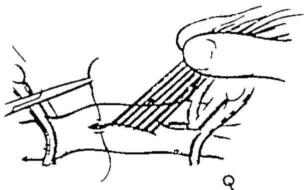


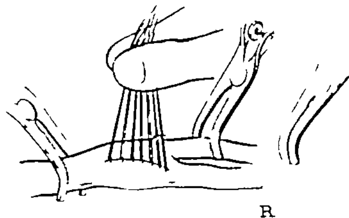












F The common carotid artery is retracted medialward, and the vagus nerve is elevated on a clamp that overlies the internal jugular vein

G The superior thyroid artery is doubly clamped and is being severed between the clamps

H. The external and internal carotid arteries are mobilized by blunt dissection, and a cotton tape is shown being withdrawn beneath the proximal portion of the external carotid artery

I. The common carotid artery and its branches are encircled by cotton tapes, and the relative size and shape of the occluding thrombus is depicted A pulsatile blood flow was present in the external but not in the internal carotid artery Potts serrefine clamps are open and held in readiness to occlude the common and external carotid arteries after exposure and partial freeing of the thrombus. The duration of occlusion of the carotid arterial flow should be kept to a minimum.

J K. An incision (broken line) is being made over the site of the thrombus and extends caudad from the origin of the internal carotid artery onto the common carotid artery for a distance of approximately 5 cm (J) The incision is deepened to the level of the thrombus and a guy suture of silk (00000) is inserted through the center of each cut margin. The common and external carotid arteries are still unoccluded.

DISCUSSION—DRS. B EISEMAN AND FRANK SPENCER. In positioning the patient extensive rotation of the head must be avoided, particularly with the neck extended, since this has been shown to decrease markedly blood flow through the carotid-vertebral axis. Though of little importance with a normal circulation, it may be a critical factor in patients with carotid or vertebral artery insufficiency A preoperative and preanesthetic trial of such an exaggerated position may be warranted

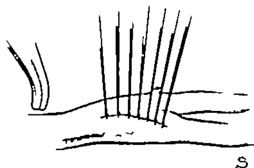
The use of local anesthesia is preferred, utilizing a posterior cervical block. Its advantages are (1) the constant ability to monitor the neurologic status of the patient to ascertain that there is no cerebral hypoxia requiring alteration or cessation of the operative procedure, (2) the (hypothetical) advantage of stellate and sympathetic block in increasing cerebral blood flow and (3) its simplicity

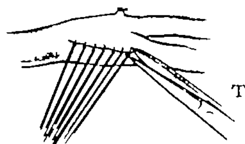
General anesthesia has the advantage of keeping the patient quiet, but restlessness may be and usually is a sign of cerebral hypoxia—a danger warning. There is no good evidence, either clinical or experimental, that anesthesia, or even deep anesthesia, decreases the metabolic demands of cerebral tissue. Indeed, all experimental evidence is to the contrary so that its use must be justified on technical, not metabolic, grounds. If general anesthesia is used, an internal shunt should be employed because some patients with bilateral arterial disease may develop serious neurologic injury from a very short period of occlusion.

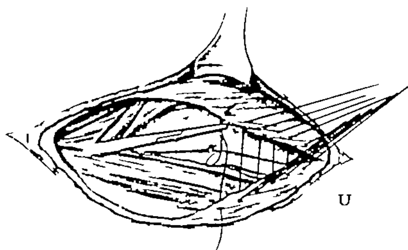
In order to attain maximum cerebral blood flow through all existing collateral vessels during occlusion, it is advised to maintain a systolic arterial hypertension of approximately 180 to 200 mm. Hg during the period of carotid occlusion. Obtainable by the anesthesiologist in a number of ways, we advise an intravenous drip of neosynephrine.

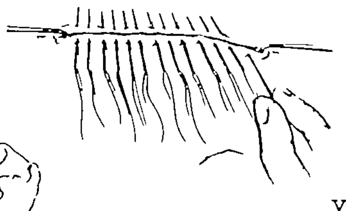
Atherosclerotic plaques may contain friable granulations that can be dislodged by manipulation of the unopened vessel and cause cerebral emboli. It is, therefore, advised that encircling tapes and occluding clamps be placed at a distance from the plaque and that the bulb be left undisturbed without circumferential mobilization. Thus properly isolated, the incision can be made on its anterior surface.

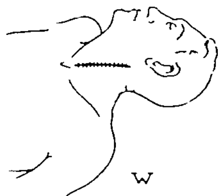
As with any endarterectomy the distal end of


S


T


U


V


W

L, M, N The thrombus is mobilized from within the lumen of the artery by an instrument * of special design. When completely mobilized about its whole circumference the thrombus is elevated on the dissector (M) Gentle traction is made on the liberated caudad portion of the thrombus as its extension cephalad into the internal carotid artery is being dissected free (N)

The absence of a retrograde flow in the internal carotid artery after the removal of a thrombus is not of the same grave prognostic import as when it occurs in the lower extremity Repeatedly patients have shown marked clinical improvement upon restoration of the blood flow in the internal carotid artery even though a retrograde flow was absent.

Upon removal of the segment of thrombus within the lumen of the external carotid artery active retrograde bleeding occurs. Accordingly the immediate occulusion of the artery with a serrefine clamp is required to prevent both the unnecessary loss of blood and imbalance of the cerebral circulation. Although extension of the thrombus into the external carotid artery frequently occurs, occlusion of its lumen is rarely present.

O Inset shows the thrombus after its removal.

P Q The lumens of the common carotid artery and its branches are first flushed with a heparin-saline solution (100 mg. of heparin in 250 cc. of saline) and a series of interrupted sutures of silk (00000) are inserted but not tied (Q)

R. Upward traction is maintained on the sutures for hemostasis as the serrefine clamps are removed

* Manufactured by Edward Weck & Co Long Island City N Y

DISCUSSION—DRS. EISEMAN and SPENCER (cont.)

the intimal dissection should be beveled and made as smooth as feasible, utilizing one or two anchoring mattress sutures if necessary with the knots *on the outside of the vessel In closure of the* arteriotomy a continuous suture is both simple and satisfactory

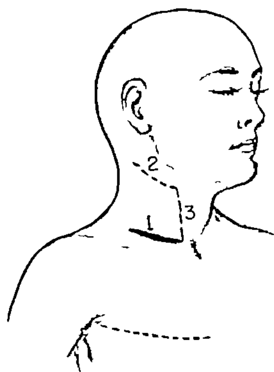
Long bilateral cervical incisions made at the same operation may cause sufficient laryngeal edema to require tracheostomy If the first operative procedure requires an extensive dissection, the operation on the opposite carotid artery should be postponed a few days

In the rare patient who will not tolerate the short period of carotid occlusion that is necessary an internal rather than an external shunt is advised Anastomosis of an external shunt to the internal carotid for temporary use is awkward and occasionally requires periods of occlusion approximately equal in length to that required for removal of the plaque itself Also closure of the distal temporary shunt site may stenose the internal carotid artery

An internal shunt of siliconized thin-walled plastic of a proper diameter can easily be slipped beyond the occlusive area and permits adequate blood flow for a major portion of the operation. This is a technic that seldom is required

The operation depicted is that of a complete occlusion of the carotid artery of recent duration. Unfortunately the majority of complete carotid occlusions are inoperable because of the cephalad extension of the thrombus in the internal carotid into the skull Most of the carotid artery lesions that are operable are those that have stenosed but not completely occluded the lumen of the artery

Plate 148



A

Trapezius m.

B

Omohyoid m. & fascial carpet"

Sternomastoid m

C

Scalenus medius

Int. jug v

D

Brachial plexus

Int jug v

E

Scalenus ant

Phrenic N

Int jug v

Com car a

Vagus N

F

S T The arterial circulation is restored and the series of interrupted sutures are tied (S) and cut (T)

U The platysma muscle layer is approximated with interrupted sutures of silk (000)

V The skin margins are coapted with a series of fine straight needles (cambric) which are withdrawn individually and the accompanying suture is tied

W The appearance of the incision on completion of the operation is depicted

DISCUSSION—DR. CHARLES ROB The incision shown follows the line of the anterior border of the sternomastoid muscle thus providing excellent exposure of the distal common carotid artery and the cervical portions of the internal and external carotid arteries. When a more limited exposure gives adequate access, as in localized plaques at the carotid bifurcation, a transverse incision centered upon the artery and following the line of the skin folds of the neck gives sufficient exposure and a better scar

The platysma muscle is divided throughout the whole length of the incision bleeding points in this layer and in the superficial fascia are secured in the usual manner The carotid sheath is opened longitudinally to expose the internal jugular vein and carotid arteries. Any tributaries of the jugular vein that cross the anterior surface of the carotid arteries must be divided. These include the common facial vein, which usually enters the jugular vein at approximately the level of the bifurcation of the common carotid artery

The common carotid artery together with its bifurcation into the internal and external carotid arteries are mobilized, and a tape is passed around the common carotid artery The internal and external carotid arteries are now separated and mobilized completely This is made possible by division of the carotid sinus nerves and of all fibrous bands surrounding these vessels. The vagus nerve lies behind the carotid bifurcation and should be carefully identified and preserved. The same applies to the hypoglossal nerve, which crosses in front of both the internal and external carotid arteries close to the digastric muscle.

Greater mobility of the carotid arteries is achieved by division of the superior thyroid artery In many patients this is unnecessary sufficient exposure being possible without sacrificing this vessel. Tapes are now passed around the internal and external carotid arteries By palpation and inspection the extent of the plaque of atheroma can now be determined. This usually involves the distal 1 cm of the common carotid artery and the proximal cm of the internal carotid artery

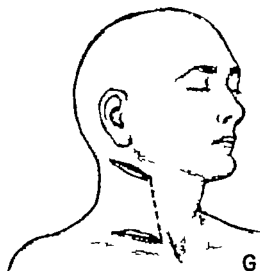
Clamps are applied first to the external then to the common and internal carotid arteries. Just before the internal carotid artery is clamped 50 mg of heparin may be injected directly into the lumen of this vessel In addition, any other branches such as the superior thyroid artery should be clamped if they have not previously been ligatured. An incision is now made through the wall of the artery overlying the area of disease. This incision lies in the long axis of the internal carotid artery A plane of cleavage is now established in the layers of the media. A thromboendarterectomy is performed so that the atheroma the intima, the internal elastic lamina, the inner layers of the media, and any blood clot are removed The adventitia, external elastic lamina, and outer layers of the media are left in position.

The plane of cleavage in the media is developed by blunt dissection, and a thromboendarterectomy of the distal common carotid and proximal internal carotid arteries is performed After completing the thromboendarterectomy it is important to remove all loose fragments and debris, thereby reducing the risk to subsequent embolization. This is best accomplished by thorough flushing with saline.

Before closing the arteriotomy incision, the clamp on the internal carotid should be opened for a few moments to flush out this vessel. The incision is then closed with 0000 silk, either continuous or interrupted sutures being satisfactory The former have the advantage that the force of the blood flow will tighten further the suture line. If it appears that the suture line will narrow the lumen, then a patch graft, preferably a segment of autogenous vein, may be used. The clamp on the internal carotid artery is removed followed by those on the common and external carotid arteries. At this point there is frequently some bleeding from the suture line, but firm pressure with a gauze square for five minutes usually stops this. If it is not sufficient extra sutures may be required.

The wound closure is in two layers, using interrupted sutures of fine silk for the platysma muscle and interrupted sutures for the skin. In many patients a drain inserted for 24 hours reduces the risk of hematoma formation.

Plate 149



Platysma

H

Submandibular gland

I Ext jug v

Int car a

Vagus N

Ext car a

Thrombus (atherosclerosis)

Com car a

J

K

Digastric m. (post. belly)

Hypoglossal N

Int. car a

Int jug v

Stump of sup thyroid a

Thyrohyoid m

Com car a

Sup belly omohyoid m

CAROTID ARTERIAL BYPASS GRAFT (DACRON)

A. This patient, a 58-year-old man, had recurrent episodes of momentary "blackouts" over a period of 18 months Right carotid and right radial arterial pulsations were diminished to absent. The diagnosis of an aortic arch syndrome (Martorell) being a likely possibility a supraclavicular incision (1) was first made after marking out (broken line) the anterolateral chest incision. Excellent carotid arterial pulsations were present proximally and a second, more cephalad transverse cervical incision (2) was made. Because of the inadequate exposure a vertical connecting incision (3) was required. The primary supraclavicular incision (1) is completed and the cervical incisions subsequently made are indicated (2, 3) The chest incision (broken line) was not required

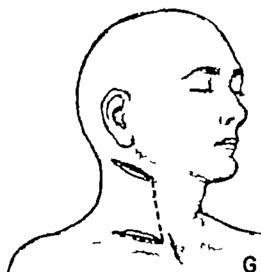
B. The incision is deepened through the subcutaneous fatty tissue and platysma muscle layers, and the underlying related structures are exposed. The severance of the tendon of the omohyoid muscle is indicated (broken line)

C. The muscle structures are retracted, and the line of incision in the middle layer of the deep cervical fascia (omohyoid fascial carpet) is shown (broken line) The transverse cervical vessels in the upper portion of the wound are visible

D, E. Upon incising the omohyoid fascial "carpet," the subjacent fat herniates into the incision This is displaced to expose the underlying anatomic structures.

F The previously isolated internal jugular vein and common carotid artery are retracted, and their relation to the vagus nerve posteriorly is seen.

Plate 149



Platysma

H

Submandibular gland

Ext jug v

I

Int car a

Vagus N

Ext car a

Thrombus (atherosclerosis)

J

Com car a

K

Digastric m. (post. belly)

Hypoglossal N

Int car a

Int jug v

Stump of sup thyroid a

Thyrohyoid m

Com car a

Sup belly omohyoid m

Sternomastoid m

L

CAROTID ARTERIAL BYPASS GRAFT (DACRON)

A. This patient, a 58-year-old man had recurrent episodes of momentary "blackouts" over a period of 18 months. Right carotid and right radial arterial pulsations were diminished to absent. The diagnosis of an aortic arch syndrome (Martorell) being a likely possibility a supraclavicular incision (1) was first made after marking out (broken line) the anterolateral chest incision. Excellent carotid arterial pulsations were present proximally and a second, more cephalad, transverse cervical incision (2) was made Because of the inadequate exposure a vertical connecting incision (3) was required. The primary supraclavicular incision (1) is completed and the cervical incisions subsequently made are indicated (2, 3) The chest incision (broken line) was not required

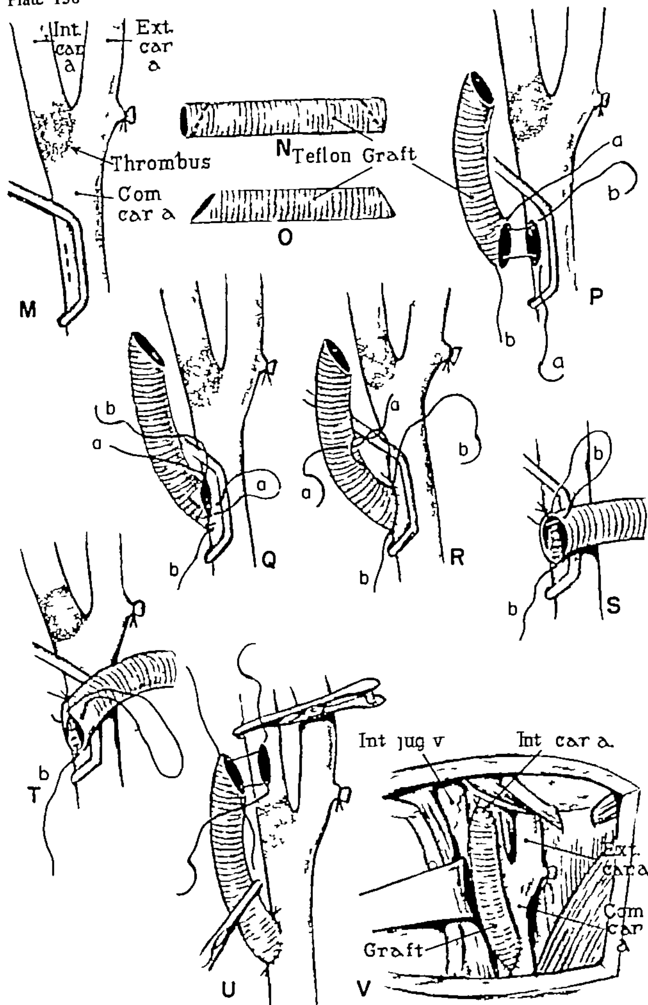
B The incision is deepened through the subcutaneous fatty tissue and platysma muscle layers, and the underlying related structures are exposed The severance of the tendon of the omohyoid muscle is indicated (broken line)

C. The muscle structures are retracted, and the line of incision in the middle layer of the deep cervical fascia (omohyoid fascial carpet) is shown (broken line) The transverse cervical vessels in the upper portion of the wound are visible

D E. Upon incising the omohyoid fascial "carpet," the subjacent fat herniates into the incision. This is displaced to expose the underlying anatomic structures.

F The previously isolated internal jugular vein and common carotid artery are retracted, and their relation to the vagus nerve posteriorly is seen.

Plate 150


Int. car a
Ext. car a
Thrombus
Com car a
N
Teflon Graft
O
M
P
a
b
b
a
Q
R
S
T
U
V
Int jug v
Int car a.
Ext. car a
Com car a
Graft

G Because of the excellent pulsation in the common carotid artery at the level of the supraclavicular incision, a second transverse cervical incision was made more cephalad and overlying the bifurcation of the common carotid artery To obtain better exposure, the two cervical incisions were later connected by a longitudinal incision as indicated by the broken line

H I. The incision is deepened through the platysma muscle (H) to expose the underlying structures (I)

J The external jugular vein is doubly ligated in continuity and severed The sternomastoid muscle is retracted to show the mobilized carotid "bulb" and the atherosclerotic thrombotic occlusion (complete) of the proximal portion of the internal carotid artery The ligated stump of the superior thyroid artery in relation to the carotid bifurcation is visible.

K, L. For better exposure of the operative field, a longitudinal incision is made anteriorly to connect the transverse cervical incisions (K) and the resulting skin and subcutaneous tissue flap is retracted posteriorly (L) to obtain an excellent exposure of the operative field.

Discussion—Drs. B Eiseman and Frank Spencer. An endarterectomy with or without a patch graft reconstruction, is always preferred to a bypass graft for a localized obstruction of the carotid artery About the only situation where such a graft might be required is in a patient where attempted endarterectomy (or excision of the carotid body tumor) so injured the artery that it could not be sutured or patched Under such unusual conditions systemic or regional heparinization should be employed while the graft is being inserted this avoids thrombus formation in the occluded arterial segment, which subsequently could embolize to the brain when the occluding clamps were released

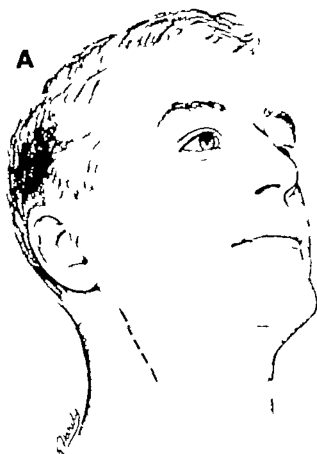
Where for some reason, an end-to-side jump graft to the carotid artery is necessary every precaution possible should be taken to avoid the necessity for complete cross-clamping of the internal carotid during the anastomosis.

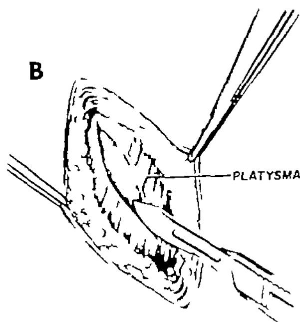
Bypass grafts of this type are occasionally indicated in extensive lesions of the aortic arch and its major branches to jump a series of obstructive segments. When thus employed, accurate preoperative roentgenographic visualization of the block should obviate the need for "searching incisions. Indeed, external inspection and palpation of these large vessels at operation may not give an accurate evaluation of the degree of obstruction. Open arteriotomy may be required to appreciate the extent of localized blocks of the "take-off" of the innominate or the common carotid arteries.

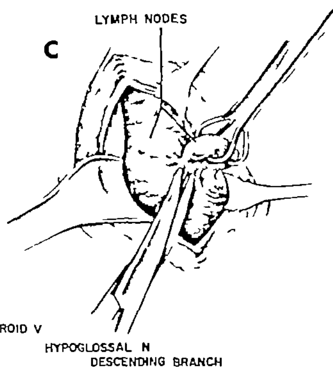
Incision for exposure of the aortic arch and its major vessels to the head and upper extremities is best obtained by a supraclavicular and a second interspace incision as illustrated, but connected by a median sternotomy The sternoclavicular joint is thus not defiled The incision is kept open by small chest retractors.

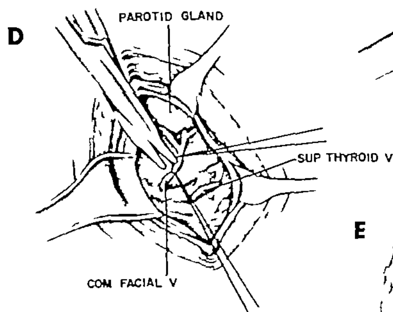
Occasionally in a high-lying aortic arch sufficient length of the distal innominate artery can be exposed solely from the supraclavicular approach after its thorough mobilization. This is not, however an area where loss of proximal arterial control is either desirable or conducive to careful technic.

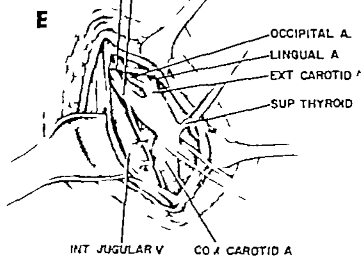
Plate 151


A


B
PLATYSMA


LYMPH NODES
C


PAROTID GLAND
D
SUP THYROID V
COM FACIAL V


HYPOGLOSSAL N
DESCENDING BRANCH
E
OCCIPITAL A
LINGUAL A
SUP THYROID
INT JUGULAR V

M. The lumen of the common carotid artery is partially occluded with a Beck Potts clamp and the incision to be made into the lumen of the occluded segment is indicated by the broken line

N O P The ends of the graft are severed obliquely at an angle of 45 (N O) and the "angle" sutures for the anastomosis caudad are inserted (P)

Q R. The lower "angle" suture is tied, and its needle strand (a) is continued cephalad as an over and-over suture (Q) and tied to the needle free strand (b) of the upper "angle" suture (R)

S T Similarly the needle strand (b) of the upper "angle" suture is continued caudad as an over-and-over suture and will be tied to the needle free strand (a) of the lower "angle" suture

U The anastomosis caudad is completed, and after the application of clamps to the graft and to the internal carotid artery distally the clamp on the common carotid artery is removed. The "angle" sutures for the anastomosis cephalad are inserted, and the anastomosis is completed as previously demonstrated.

V The operative field on completion of the insertion of the by-pass graft (teflon) is shown. An arteriogram 14 months post operatively showed complete patency of the graft.* The patient has been asymptomatic since the operation.

* Eighteen months postoperatively complete thrombosis within the lumen of the graft occurred and was associated with the recurrence of cerebral symptoms. The graft was replaced with an autogenous vein (saphenous) graft, and concomitant clinical improvement was observed. Because of the delayed and imperfect maturation of the pseudointima in the teflon grafts, their use in the small peripheral arteries (e.g., carotid femoral) is not advocated.

Discussion—Dr. Charles Rob A bypass graft for occlusion of the carotid arteries is most frequently used where there is an extensive disease of the distal common carotid as well as the proximal internal carotid artery Two incisions are required over the common carotid artery at the base of the neck and the other over the carotid bifurcation.

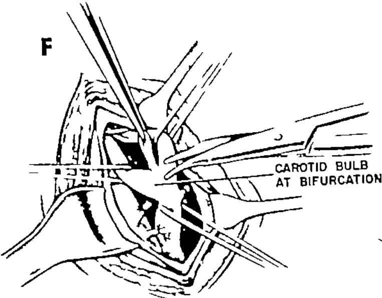
In the exposure of the common carotid artery the incision is placed about 1 in. above the clavicle and over the sternomastoid muscle. After division of the platysma muscle, the sternomastoid muscle is identified, behind which the carotid sheath lies. The common carotid artery may be exposed, as illustrated, by retraction medially of the lateral border of the sternomastoid muscle. An alternative and perhaps a better way is to retract the medial border of the sternomastoid muscle laterally Once identified the common carotid artery is mobilized for a distance of about three inches.

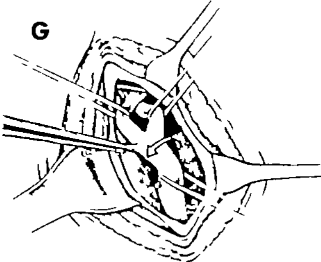
In the exposure of the carotid bifurcation the incision follows the lines of the skin folds of the neck and is centered upon the carotid bifurcation The platysma muscle is divided, as is the external jugular vein The sternomastoid muscle is retracted posteriorly and the carotid sheath identified. At this point it is often necessary to divide the common facial vein. The distal common carotid artery together with the proximal internal and external carotid arteries are then mobilized, great care being taken to preserve the vagus and hypoglossal nerves. Sufficient of the internal carotid artery must be mobilized to permit of an end-to-side anastomosis distal to the area of arterial disease

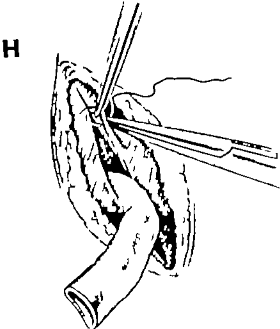
A tunnel for the graft is then made between the two incisions. The bypass graft is anastomosed end-to-side to the common carotid artery proximally and to the internal carotid distally A variety of materials have been used to bypass the carotid artery these include prostheses of teflon and dacron and segments of autogenous vein. A teflon prosthesis, as illustrated here, gives good early results, but long-term follow-up studies show that the use of an autogenous vein is better A suitable length of the long saphenous vein is removed and reversed so that the proximal end is anastomosed to the side of the internal carotid artery and the distal end to the side of the common carotid artery

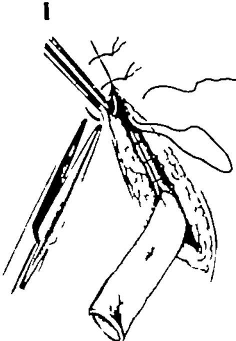
The anastomosis is performed with a continuous over-and-over suture of 0000 silk if a vein graft is used or mersilene if a plastic prosthesis is inserted. After completion of both anastomoses, the distal clamp is removed first followed by the proximal clamp If bleeding occurs firm pressure is applied with a gauze square for five minutes. Later if haemostasis is not complete, further sutures may be needed but these are rarely necessary

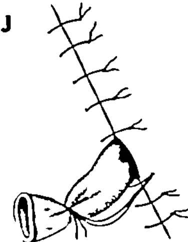
Plate 152











CAROTID GLOMECTOMY

A. The skin incision (broken line) which begins at the angle of the mandible and parallels the anterior border of the sternomastoid muscle, extends obliquely caudad for one-third the distance from the angle of the mandible to the sternoclavicular junction

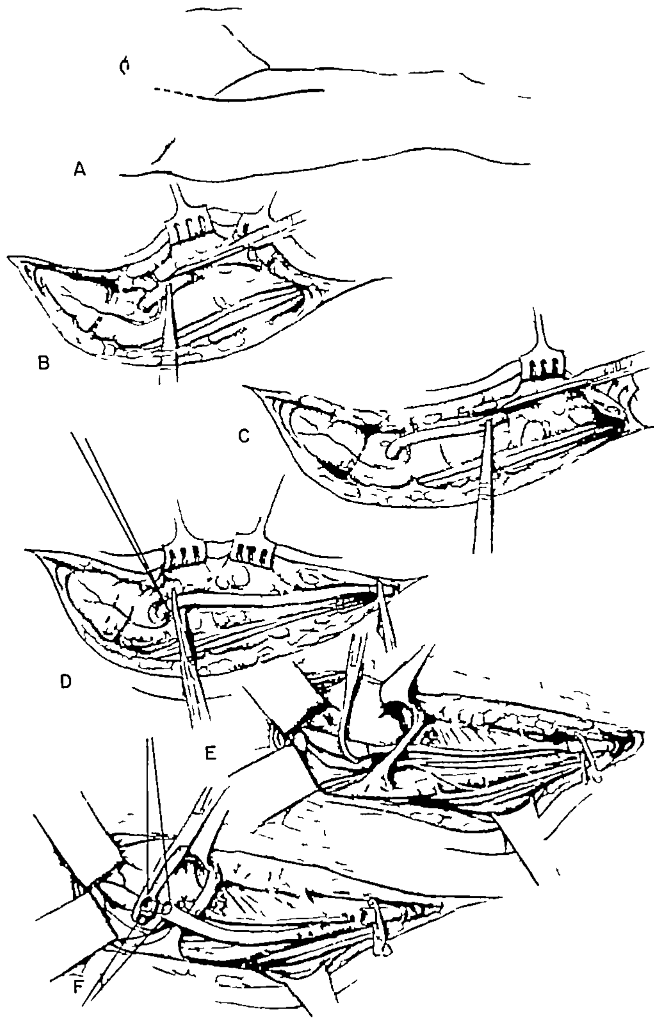
B. The incision is deepened through the subcutaneous fatty tissue layer and the underlying platysma muscle is shown being severed with a scalpel.

C. The sternomastoid muscle is retracted laterally and one of a group of cervical lymph nodes, held in a clamp (Babcock) is being mobilized by scissor dissection Although not commonly a problem in the exposure of the carotid bulb in this particular patient there was an unusually large group of lymph nodes, the removal of which was necessary before continuing the dissection.

D The common facial vein, doubly ligated in continuity is being severed between the ligatures with scissors. This vein, formed by the junction of the anterior and posterior facial veins is a tributary of the internal jugular vein A second tributary the superior thyroid vein, is also visible.

E. The dissection is completed to expose the carotid bulb and related structures. The ligated stumps of the internal jugular vein tributaries previously described are visible. The common carotid artery and the superior thyroid artery are encircled with cotton tapes preparatory to dissection of the carotid bifurcation. The superior thyroid artery usually described as the first branch of the external carotid artery not uncommonly arises from the common carotid artery proximal to its bifurcation, as illustrated. The hypoglossal nerve is seen to cross the external carotid artery just cephalad to its occipital and lingual branches The descending branch of the hypoglossal nerve is visible in relation to the internal jugular vein and the internal and common carotid arteries

Plate 153



F The carotid artery and its branches are encircled by cotton tapes for traction as the adventitia at the carotid bifurcation is removed by scissor dissection. As the dissection proceeds posteriorly it will include the small flattened carotid body the glomus.

G The dissection posteriorly may be facilitated by traction on the ligated stump of the superior thyroid artery and rotation (arrow) of the carotid bulb about a 180 axis.

H, I. After the glomectomy has been completed, the traction tapes are removed, and a soft rubber tissue drain is inserted down to the operative area The platysma muscle layer is being closed about the drain using interrupted sutures of 000 silk (H) Similarly the skin is next closed with interrupted sutures of 000 silk (I)

J The completed closure of the incision with the drain anchored in its lower portion by one of the skin sutures is shown. A thyroid dressing is subsequently applied to complete the operation. The drain is removed in 48 hours Alternate skin sutures are removed on the third postoperative day and the remainder of the sutures on the following (fourth) day

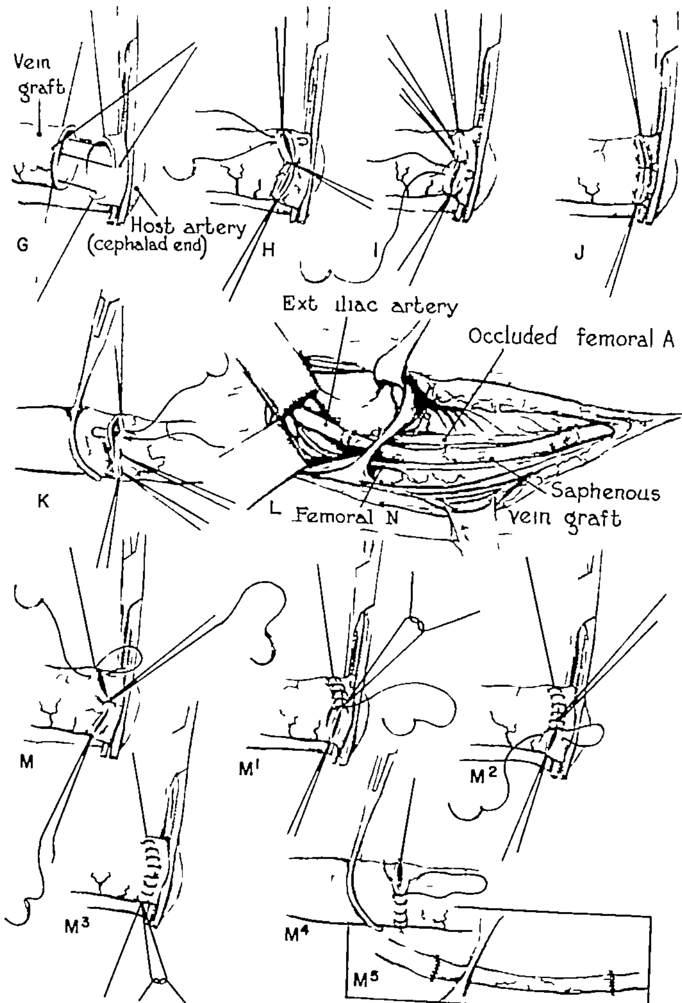
DISCUSSION—DR. RICHARD H OVERHOLT There is growing clinical evidence that a substantial majority of asthmatics can be helped by a cervical glomectomy Large groups of patients so treated in Japan, Poland, Germany and in this country have been reported The mechanism of benefit is not clearly understood. In the asthmatic subject carotid reflexes may be hypersensitive, so that minor disturbances induced by irritants, allergens, emotions, or exertion may trigger bronchospasm on slight provocation. The removal of a carotid body dampens this reflex.

The operation has been advised for cases of intractable asthma that constitute medical failures or for cases of controlled asthma when the drug program has become an intolerable burden.

The illustrations are clear and will guide a surgeon experienced in neck procedures to the area of the carotid body They reveal the relationship of contiguous structures and indicate that the procedure can be consummated without injury to them

I prefer a slightly more transverse incision, paralleling the lower angle of the mandible and placed two finger breadths below it If the incision precisely follows a natural crease line of the skin, the resulting scar will be completely or nearly invisible. Fibers of the platysma need not be divided but can be split and retracted

A drain is shown in the last three illustrations. Careful hemostasis will eliminate with advantage the necessity for a drain in such a small wound.


Vein graft
Host artery (cephalad end)
G
H
I
J
Ext iliac artery
Occluded femoral A
K
L
Femoral N
Saphenous vein graft
M
M1
M2
M3
M4
M5

RESTORATION OF PERIPHERAL ARTERIAL CONTINUITY BY RESECTION AND GRAFT (VEIN) REPLACEMENT OR A SHUNT BYPASS

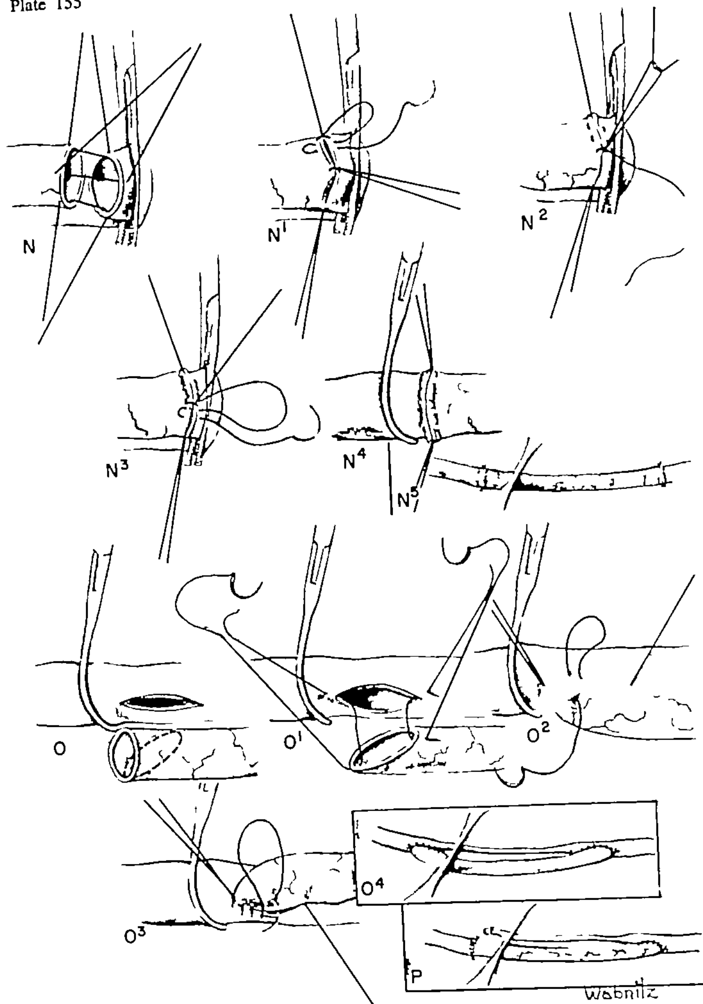
A. The anterior thigh incision employed (solid line) and its abdominal extension (dotted line) are depicted

B C, D The long saphenous vein is mobilized by sharp dissection from the subcutaneous fatty tissue layer medially (B C) and a 16-cm length of the vein is removed as indicated (D). Either a suture knot is placed in the adventitia coat of the vein or the ligated stumps of the tributary veins are used as landmarks to determine the cephalad and caudad ends of the vein The vein is then immersed in a solution of heparin and saline (100 mg. of heparin in 250 mL of saline) until ready for use. The direction of the vein is always reversed prior to insertion to prevent the possibility of an obstruction to the flow of blood caused by competent valves within its lumen

E. The long length of the constricted and obliterated arterial segment involving the distal portion of the external iliac artery the common femoral artery and the proximal two-thirds of the superficial femoral artery is visible. The patent arterial segments cephalad and caudad are occluded with clamps, and the intervening segment is transected at the sites indicated (dotted lines).

F Preparatory to the performance of the blood vessel anastomosis, 10 ml of the heparin-saline solution is injected into the lumen of the artery caudad. The direction of the vein graft is reversed and the caudad end is now cephalad Two of the three equidistantly placed cardinal guy sutures which are used to approximate the ends of the vessels are inserted but not tied The vein graft shown anterior to the inguinal ligament is subsequently withdrawn beneath it immediately after the completion of the cephalad end of the anastomosis

Plate 155



G H I J K. These are close up views to show the details of the anastomosis. The free end of the vein graft is turned upward, and the three cardinal guy sutures are inserted but not tied (G). One of the guy sutures is inserted in the midline posteriorly and each of the remaining two are inserted at either lateral angle (G). The cardinal guy sutures are tied (H), and the ends of the vessels are approximated posteriorly with everting mattress sutures of 00000 silk swedged on minimum trauma needles (H I J) The free end of the vein graft is then turned downward, and, in like manner the anterior layer of the anastomosis is being completed (K).

L. The insertion of the autogenous vein (saphenous) graft is completed, and its relation to the occluded segment of the femoral artery and to the inguinal ligament are demonstrable

M M^1 M^2 M^3 M^4 M^5 These close up views demonstrate an alternate method of performing a blood vessel anastomosis by the use of a continuous over and over suture of arterial (00000) silk The suture is started posteriorly (M) with the needle strand of one of the lateral guy sutures and is continued to the midline where it is tied to the free strand of the posterior guy suture (M) The needle strand of this suture is continued (M^2) toward the opposing lateral guy suture and tied to its free strand (M). The vein graft is then turned downward, and the needle strand of the second lateral guy suture is continued anteriorly toward the opposing lateral angle suture (M) where the anastomosis was originally started. The completion of the insertion of the vein graft using a simple over and over suture is shown (M). This particular technic the more desirable, is a simple rapid and effective method of anastomosis



A

CRURAL FASCIA

SAPHENOUS V

B

GASTROCNEMIUS M

C

SOLEUS M

FASCIAL ATTACHMENT TO TIBIA

NEUROVASCULAR BUNDLE

PLANTARIS M.

D

SEMITENDINOSUS AND SEMIMEMBRANOSUS MUSCLES

POPLITEAL VEIN A ARTERY

E

POSTERIOR TIBIAL NERVE AND ARTERY

PERONEAL A

E_1

N N^1 N^2 N^3 N^4 N^5 The technic of performing the anastomosis illustrated is the same as that previously described (M M M M M M) with the exception that a continuous everting mattress rather than an over and over suture is employed This technic, included for completeness is the least desirable

O O^1 O^2 O^3 O^4 These illustrations depict the technic for the performance of an end to-side bypass of an occluded arterial segment. The artery cephalad is cross-clamped and, just below the clamp a lateral opening is made into the arterial lumen (O) The end of the vein graft is cut on a bias (dotted out line) to obtain a flat approximation to the side of the artery (O). The angle guy sutures (00000 silk) are inserted but not tied (O). The needle strand of the lower guy suture is inserted from below upward as an over and over suture toward the upper angle guy suture (O) where it is tied to its free end The needle strand of the upper angle guy suture is then inserted on the opposite side from above downward as an over and over suture toward its starting point at the lower angle (O) where it is tied to the free strand of the lower angle guy suture The inset (O) shows the completion of the end to-side by pass shunt utilizing an autogenous vein (long saphenous) graft.

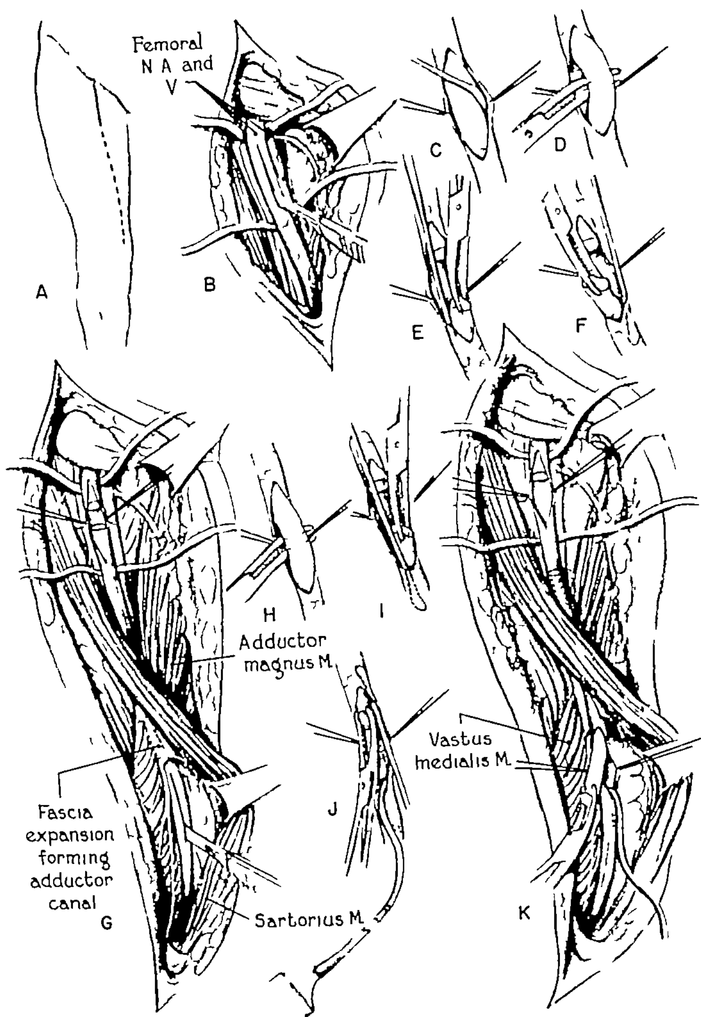
P This inset shows a modified bypass shunt in which an end to-end anastomosis is performed cephalad and an end to-side anastomosis caudad. This method was used in one patient in whom a thrombus formed in the lumen of an end to-side bypass shunt vein within 8 to 10 minutes after its insertion. The cephalad end of the anastomosis was disconnected, the thrombus evacuated and the lumen of the vein was irrigated with heparin–saline solution The reanastomosis cephalad was performed end to-end rather than end to-side, with a satisfactory result.

In the restoration of continuity in the lower iliac and femoral arteries either by resection and graft or a shunt bypass, the use of an autogenous vein (long saphenous) as illustrated (A to L), rather than an arterial homograft or cloth prosthesis, is preferred. The illustrations (A to L) depicting the insertion of the autogenous vein graft were from sketches made at the time of operation upon a 65-year-old man. This patient was admitted to the hospital because of severe pain secondary to an ischemic ulcer (4 by 3 cm) of two years duration overlying the anterior aspect of the midportion of the right leg A lumbar sympathetic ganglionectomy performed 18 months previously had no beneficial effect. In fact, because of the severity of the pain, the patient requested that the leg be amputated. Following the insertion of the vein graft as depicted (A to L), pulsations in the dorsalis pedis and posterior tibial arteries were restored. Post operatively the relief of pain was immediate, and the ulceration of the leg healed completely in 11 days At the end of a follow up period of two and one half years, the patient was still asymptomatic and the peripheral arterial pulsations were easily palpable.

DISCUSSION DR JOHN P WEST With experience and skill, a surgeon can expect to restore circulation about an occluded femoral artery with the various technics so clearly shown in these drawings The recorded experience to date indicates that a higher percentage of good results are obtained by end to-side anastomosis as shown in Plate 154O[1] The anastomotic orifices need to be wide, and better results follow the use of large caliber grafts

When well supported by muscle, an autogenous vein graft may be the ideal arterial substitute However the removal of the vein adds to the operative trauma, and at times the saphenous vein is not of ideal caliber Further experience is needed to determine the relative merits of homologous arteries and cloth prostheses

Plate 157


Femoral
N A and
V
A
B
C
D
E
F
H
I
Adductor
magnus M
J
Vastus
medialis M
Fascia
expansion
forming
adductor
canal
G
Sartorius M
K

SURGICAL EXPOSURE OF THE POPLITEAL VESSELS AND POSTERIOR TIBIAL NERVE IN THE UPPER THIRD OF THE LEG

A. The two exploratory incisions in the thigh are packed loosely with moist gauze sponges, and the incision in the anteromedial aspect of the proximal third of the leg is indicated by the solid black line

B The incision is deepened through the subcutaneous fatty tissue layer and the crural fascia is being incised (broken line) The saphenous vein and the ligated stumps of its tributaries are visible.

C. The cut margins of the crural fascia are retracted to expose a broad expanse of the gastrocnemius muscle A small segment of vein in the central portion of the muscle is visible

D The gastrocnemius muscle is retracted to show the fascial attachment of the soleus muscle to the tibia being incised. This is necessary to obtain adequate exposure of the underlying neurovascular bundle The relation of the plantaris muscle to the operative field is depicted

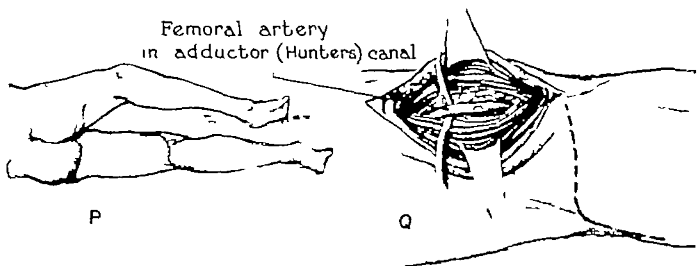
E. The fascial incision is completed and a good exposure of the structures that comprise the neurovascular bundle is obtained

E_1 This close-up view shows the usual relation of the nerve, vein, and artery The artery is posterior in relation to the vein and nerve, each of which is encircled by a cotton tape and retracted to obtain the necessary exposure of the artery that is required. The anterior tibial artery not depicted, arises from the popliteal artery immediately proximal to the arterial segment that is visible

In explorations of the femoral artery in the thigh for a bypass graft, thromboendarterectomy or excision and graft replacement, the peripheral arterial run-off may prove unsatisfactory Under such circumstances it is considered advisable to explore the popliteal artery in the leg, utilizing the approach as illustrated * It is believed by many that the extension of the disease process to this level would preclude a satisfactory operative result. In such circumstances, however the excellent results not infrequently obtained are believed to justify the continued use of this operation.

This approach was originally described by Szilagyi in 1959 See references on Reconstructive Arterial Surgery

Great saphenous V
Adductor magnus M
Sartorius M
M
N
Catheter
Saphenous N
L
O
Vastus medialis M.



FEMORAL THROMBOENDARTERECTOMY

A The incision overlying the femoral triangle (solid line) and its subsequent extension caudad (dotted line) are indicated If desired separate cephalad and caudad incisions may be employed However in the experience of the author the single long incision has proved the more satisfactory It is not associated with an increase in the operative morbidity and the objection to the length of the incision based on cosmetic reasoning is believed not of practical significance

B C. The femoral artery is incised (B), and after the insertion of guy sutures of silk (00000) in either incised margin the underlying thrombus is mobilized with a dissecting instrument of special design (C). In making the incision in the artery (B), the thinness of its wall overlying the thrombus should be emphasized. Otherwise the thrombus itself may be incised and the improper cleavage plane entered. Characteristically the inner lining of the wall of the artery surrounding the thrombus has a glistening sheen which is indicative of the proper plane for dissection.

Manufactured by Edward Weck & Co Brooklyn, New York

D The mobilized portion of the thrombus, which occludes the lumen of the femoral artery is elevated on a clamp (Mixter), and a small segment is excised (dotted line).

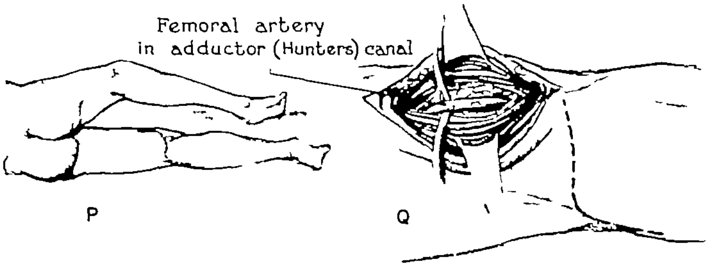
E, F The transected end of the caudad portion of the thrombus is secured in a curved clamp and with the use of the dissecting instrument, the thrombus is separated from the arterial wall.

G H I. In like manner a second separate incision is made in the lower portion of the femoral artery within Hunter's canal (G), and the underlying thrombus is mobilized (H I) as previously described. If need be, three rather than two femoral arteriotomies may be made.

J, K. A catheter (No 14 F) is inserted into the lumen of the femoral artery distally and through it a solution of heparin (100 mg. of heparin in 250 ml. of normal saline) is intermittently instilled (J) Through the lower femoral arteriotomy the thrombus is mobilized cephalad (J) to the level of the completed dissection previously made in a caudad direction through the upper femoral arteriotomy and the intervening thrombotic segment is withdrawn (K)

Plate 158

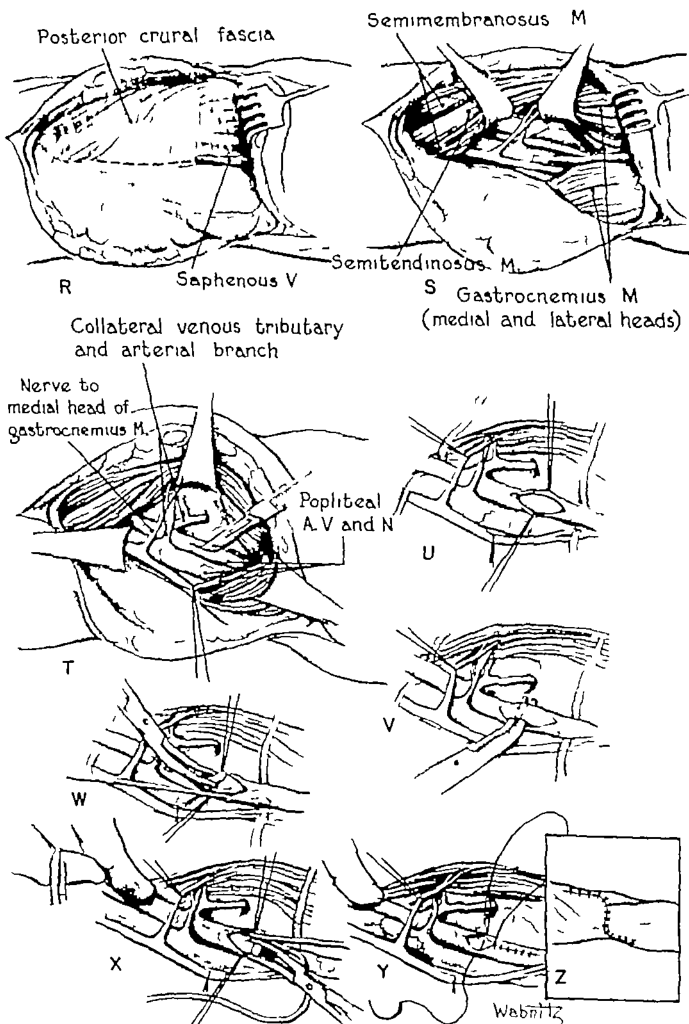
Great saphenous V
Adductor magnus M
Sartorius M
M
N
Catheter
Saphenous N
L
O
Vastus medialis M



L The lower arteriotomy is closed with a continuous suture of 00000 arterial silk swedged on a minimum trauma needle Similarly the caudad portion of the upper arteriotomy is closed, and the dissection of the cephalad portion of the thrombus within the femoral artery is begun. A catheter (No 14 F) through which a solution of heparin is intermittently instilled, is inserted within the cleared lumen of the femoral artery distally

M N O The dissection of the thrombus is continued (M) and, when it is completed bleeding is controlled by gentle digital compression (N) A kidney-stone grasping forceps is inserted cephalad in the lumen of the femoral artery to remove any remaining thrombotic debris (N) Upon completion of the thromboendarterectomy bleeding is controlled by digital compression rather than clamp occlusion of the femoral artery cephalad as the closure of the upper arteriotomy is being completed (O) In this patient, a 74-year-old man, an excellent pulsation throughout the whole length of the femoral artery was restored.

P Q In patients in whom the femoral arterial pulsations are present and the popliteal, dorsalis pedis, and posterior tibial pulsations are absent, exploration of the femoral artery in Hunter's canal is performed The patient is placed in the lateral recumbent position, and the lower extremity that is uppermost is supported on pillows (P) The linear incision overlying Hunter's canal (solid line) and its subsequent S-shaped extension (dotted line) to expose the popliteal artery are depicted (P) Upon exploration of the femoral artery in Hunter's canal (Q) adequate arterial pulsations were present Accordingly an S-shaped extension, depicted by the dotted line (Q), was made for exposure of the popliteal artery

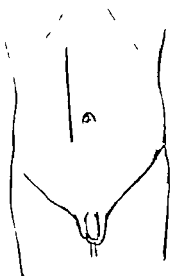

Posterior crural fascia
Semimembranosus M
Saphenous V
Semitendinosus M.
R
S
Gastrocnemius M
(medial and lateral heads)
Collateral venous tributary
and arterial branch
Nerve to
medial head of
gastrocnemius M.
Popliteal
A. V and N
U
T
V
W
X
Y
Z
Wabnitz

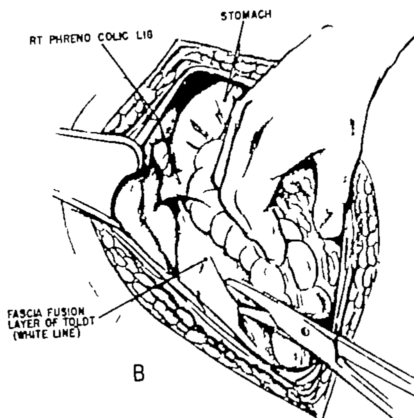
L. The lower arteriotomy is closed with a continuous suture of 00000 arterial silk swedged on a minimum trauma needle. Similarly the caudad portion of the upper arteriotomy is closed, and the dissection of the cephalad portion of the thrombus within the femoral artery is begun. A catheter (No 14 F), through which a solution of heparin is intermittently instilled, is inserted within the cleared lumen of the femoral artery distally.

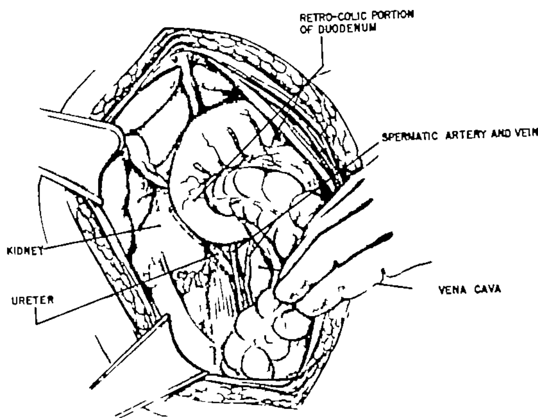
M N O The dissection of the thrombus is continued (M), and when it is completed bleeding is controlled by gentle digital compression (N). A kidney stone grasping forceps is inserted cephalad in the lumen of the femoral artery to remove any remaining thrombotic debris (N). Upon completion of the thromboendarterectomy bleeding is controlled by digital compression rather than clamp occlusion of the femoral artery cephalad as the closure of the upper arteriotomy is being completed (O). In this patient, a 74-year-old man, an excellent pulsation throughout the whole length of the femoral artery was restored.

P Q In patients in whom the femoral arterial pulsations are present and the popliteal, dorsalis pedis, and posterior tibial pulsations are absent, exploration of the femoral artery in Hunter's canal is performed. The patient is placed in the lateral recumbent position, and the lower extremity that is uppermost is supported on pillows (P). The linear incision overlying Hunter's canal (solid line) and its subsequent S-shaped extension (dotted line) to expose the popliteal artery are depicted (P). Upon exploration of the femoral artery in Hunter's canal (Q) adequate arterial pulsations were present. Accordingly an S-shaped extension, depicted by the dotted line (Q), was made for exposure of the popliteal artery.

Plate 160


A


STOMACH
RT PHRENO COLIC LIG
FASCIA FUSION
LAYER OF TOLDT
(WHITE LINE)
B


RETRO-COLIC PORTION
OF DUODENUM
SPERMATIC ARTERY AND VEIN
KIDNEY
URETER
VENA CAVA
C

R. The S-shaped incision in the popliteal space is completed the flaps are mobilized, and the incision in the posterior crural fascia is shown in dotted outline

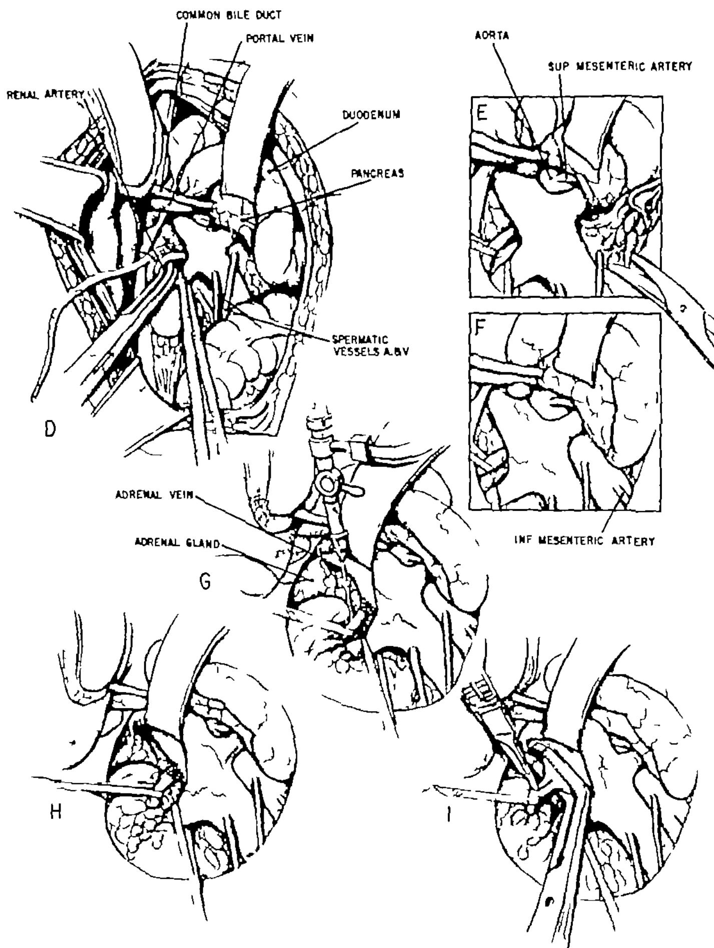
S. The incision in the posterior crural fascia is completed and the neurovascular contents of the popliteal fossa are exposed.

T The tibial nerve is encircled by a guy suture of silk (00) and retracted to show the subjacent popliteal vein and artery The branch of the tibial nerve which bifurcates before its entrance into the medial head of the gastrocnemius muscle is shown. Similarly the collateral tributary and branch of the popliteal vein and artery respectively are depicted. Although an excellent pulsation in the collateral arterial vessel was present the lumen of the popliteal artery immediately caudad was occluded with a thrombus

U V W X Y The incision in the popliteal artery and the mobilization of the thrombus is the same as previously described (B C, D E, F). Similarly heparin solution is instilled intermittently through a catheter (No 12 F) into the cleared lumen of the popliteal artery caudad as the thrombus is being dissected cephalad (X) Upon completion of the removal of the thrombus, bleeding is controlled by proximal digital compression as the arteriotomy is closed, using a continuous over and over suture of 00000 arterial silk swedged on a minimum trauma needle. In this patient, a 53-year-old man with a serpiginous ulceration overlying the lateral aspect and lower third of the left leg, an excellent pulsation was restored in the popliteal artery

Z. Inset to show the completion of the closure of the S-shaped incision in the popliteal fossa

Discussion.—Dr John P West The illustrated technic of thromboendarterectomy is a most satisfactory one. However it has been our experience that, in general, attempts to clear the lumen of long segments of small vessels, such as the superficial femoral and popliteal arteries, are often unsuccessful The incidence of prompt recurrent occlusion has been high For this reason, we favor a bypass operation when a good and patent artery can be found at either end of the obstruction. The ideal case for thromboendarterectomy is one in which there is a short segmental occlusion. Such obstructions are often found at the bifurcation of the common femoral artery In some cases, removal of a segment of thrombus facilitates the insertion of a graft, and, in such cases, a judicious combination of thrombectomy and grafting is likely to give the best result.


COMMON BILE DUCT
PORTAL VEIN
RENAL ARTERY
DUODENUM
PANCREAS
SPERMATIC VESSELS A.&V
D
AORTA
SUP MESENTERIC ARTERY
E
F
INF MESENTERIC ARTERY
ADRENAL VEIN
ADRENAL GLAND
G
H
I

RENAL THROMBOENDARTERECTOMY

The patient, a 46-year-old white man, was admitted to the hospital because of severe and persistent headache pain in the cervical region posteriorly and numbness in the left upper extremity. These symptoms had been present for the preceding 10 days. The blood pressure was 240/120. One year previously the diagnosis of essential hypertension was made.

A selective renal function study was done. On the left side the urinary volume and sodium excretion were normal. There was no excretion of urine on the right side. A translumbar aortogram showed opacification of the left renal artery but not the right. Accordingly the right renal artery was explored and the operation as illustrated was performed.

The right renal artery was occluded for a distance of 2 cm. by an atherosclerotic thrombus which extended partly into the lumen of the aorta. The artery distal to the thrombus was soft, pliable, and patent but had no pulsatile flow of blood.

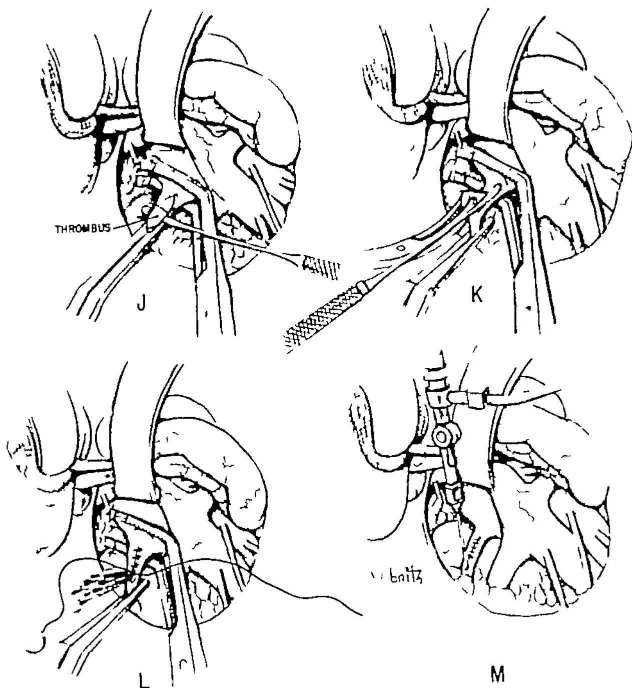
Postoperatively the patient had an uneventful convalescence. The day after operation the blood pressure was 130/90. The decrease in the blood pressure was concomitant with complete relief of the headache. It is now 4 years since the operation was performed and the patient is asymptomatic. The blood pressure is 130/80.

A. The patient is placed in the supine position and the right paramedian abdominal incision is indicated by the solid line.

B. The peritoneal cavity is entered, and the right side of the colon and its hepatic flexure are mobilized by scissor dissection along the "white line" and subsequent transection (broken line) of the phrenocolic ligament.

C. The mobilized right side of the colon is retracted toward the midline, and several of the retroperitoneal structures are depicted. The broken line indicates the incision for the mobilization of the duodenum.

Plate 162



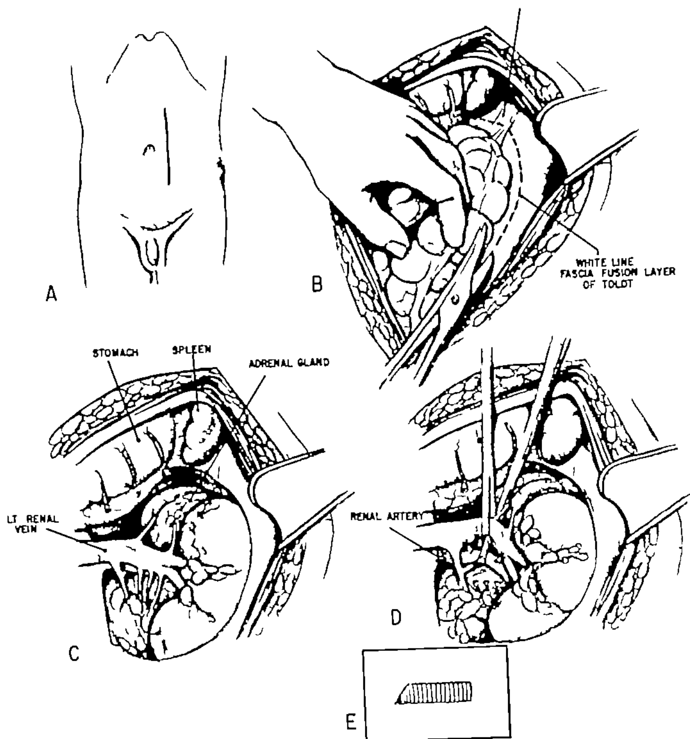
D The mobilized duodenum is rotated and retracted medially to expose the operative field The mobilized right renal artery cephalad and posterior to the renal vein, is being encircled by a cotton tape as was the renal vein previously

E, F Close-up views to show the clearance of the abdominal aorta and its spermatic and inferior mesenteric arterial branches (F) by scissor dissection of the preaortic lymph nodal tissue mass (E) The superior mesenteric artery branch and its relation to the left renal vein, over which it arches, are clearly visible (E, F)

G H. The inferior vena cava cephalad is retracted medialward to expose a segment of the aorta and its right renal arterial branch. The pressure distal to the block is first measured (G) later it will be measured proximally to determine the pressure gradient across the block. The site of the block is indicated by the stippling (H) The right adrenal gland and its vein, a tributary of the inferior vena cava, may also be seen.

I. A segment of the abdominal aorta in juxtaposition to the origin of the renal artery is occluded tangentially with a Beck Potts clamp, and the renal artery tensed by traction on the encircling tape, is incised longitudinally

Plate 163


A
B
WHITE LINE
FASCIA FUSION LAYER
OF TOLDT
STOMACH
SPLEEN
ADRENAL GLAND
LT RENAL
VEIN
C
RENAL ARTERY
D
E

J The incision in the renal artery is deepened to the surface of the thrombus, and the thrombus is mobilized throughout its circumference, using a specifically designed instrument.* The mobilized segment of the thrombus is elevated on the instrument, and its site of transection is indicated by the broken line

K. The distal segment of the thrombus is removed and the proximal segment is being dissected. During this dissection, the clamp on the aorta is temporarily released to permit the extraction of the intra-aortic projection of the thrombus. Subsequent to the extraction of the thrombus the aorta is again occluded as previously (J)

* Manufactured by Edward Weck & Co Long Island City N Y

L. Upon completion of the thromboendarterectomy the opening in the artery is closed with interrupted sutures of a 00000 arterial silk swedged on a minimum trauma needle. Prior to completion of the closure, the clamp on the aorta is again temporarily released to determine the patency of the arterial lumen and to wash out any existing clots. The angulated Potts clamp distally remains occluded

M. The operative field on completion of the operation is shown. The renal arterial pressure was again recorded and the pressure gradient (80 mm. Hg.) was observed to have been eliminated

DISCUSSION—DR. PAUL T DE CAMP The inferior vena cava creates a problem in approaching the right renal artery because it lies across the major portion of the artery From the lateral approach the vena cava can be retracted to the left, as illustrated in D From the midline approach it may be retracted either to the right or to the left, whichever will give the best exposure to the involved portion of the artery A bypass graft should be placed behind the vena cava.

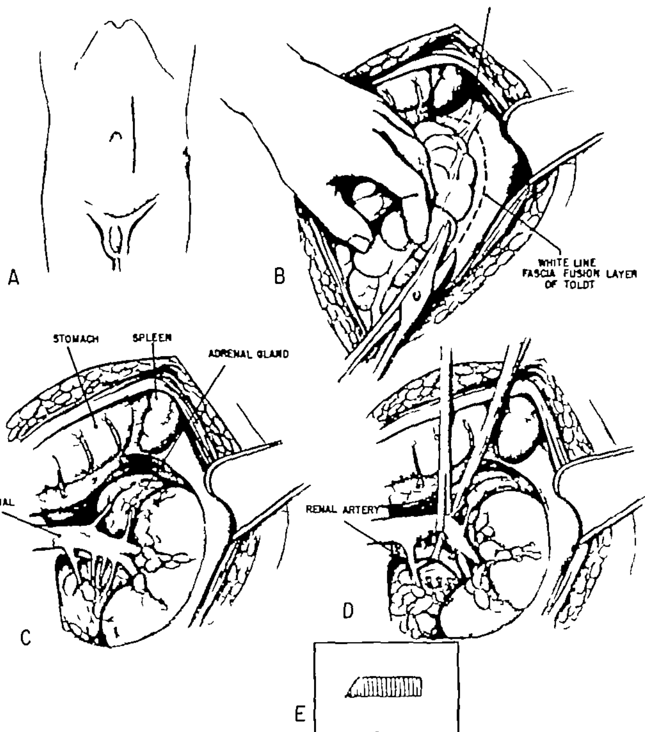
The important observation of the intrarenal arterial pressure is illustrated in G In my opinion and experience in true cases of renovascular hypertension the distal pressure will be found significantly lower than the proximal In 89 per cent of the cases the mean pressure difference has been greater than 50 mm. of mercury

The superior mesenteric artery may be so close to the renal that it interferes with the placement of the exclusion clamp to partially occlude the aorta and may compromise the exposure of the orifice of the renal artery It may be necessary to cross clamp the aorta, but if this is done the contralateral renal artery must not be occluded fo too long a period. The opposite kidney unlike the kidney served by a severely stenosed renal artery is not protected by a collateral circulation.

Endarterectomy of an arteriosclerotic renal artery (I K) must be effected with extreme caution, as the renal artery is often friable and may be torn to bits. My arterial incision extends onto the aorta where it curves caudad. This permits easier endarterectomy of the aortic orifice of the artery I always employ a vein patch for closure with its use I am insured of a most adequate lumen and am not tempted to "push" the endarterectomy and possibly tear up the vessel.

The renal artery may be small, and closure must be meticulous. Interrupted sutures are preferable in small vessels or at critical angles of suture to minimize the production of strictures or kinks.

Alternatively renal endarterectomy may be performed through an obliquely placed transecting incision in the artery just distal to the occlusion plaque Proximal dissection is performed and the vessel is reanastomosed with interrupted sutures.


A
B
WHITE LINE
FASCIA FUSION LAYER
OF TOLDT
STOMACH
SPLEEN
ADRENAL GLAND
LT RENAL
VEIN
C
RENAL ARTERY
D
E

AORTORENAL BYPASS GRAFT

A. The patient is placed in the supine position, and the left paraumbilical incision is indicated by the solid black line.

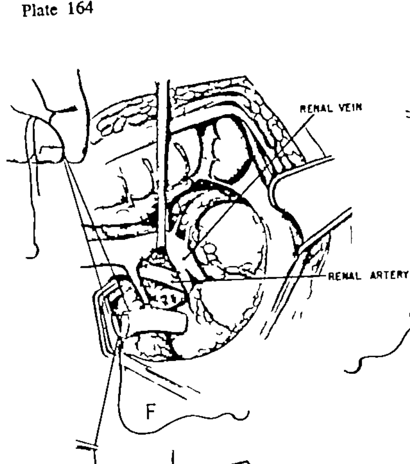
B. The peritoneal cavity is entered, and the proximal portion of the descending colon is mobilized by scissor dissection along the "white line" as depicted. This dissection is extended to sever the phrenocolic, the lienocolic, and the gastrocolic ligaments in order to facilitate the mobilization of the splenic flexure the distal half of the transverse colon, and the related portion of the greater curvature of the stomach.

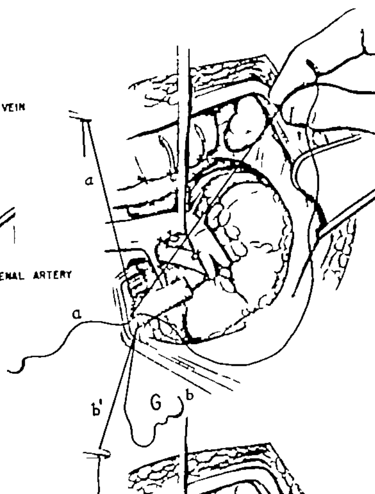
C. The mobilized portion of the colon is retracted to the right, and the retroperitoneal structures are exposed. The left renal vein is anterior to and obscures almost completely the left renal artery Its relation to the kidney and the adrenal gland is clearly visible In this patient there was a multiplicity of renal vein tributaries, which were too numerous to name Superiorly there were two adrenal veins Inferiorly instead of one internal spermatic vein, there were four tributaries. The posterior location of the renal artery and the multiplicity of the renal tributaries made the exposure of the artery somewhat difficult.

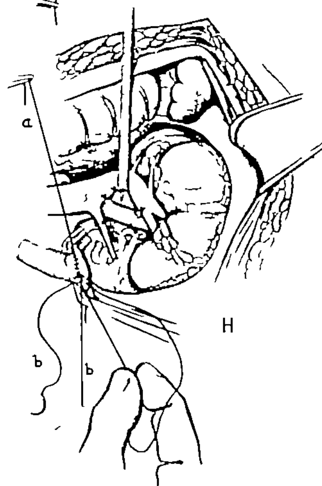
D The adrenal tributary vein (or veins) is routinely preserved Three of the tributaries inferiorly were doubly ligated in continuity and severed. The mobilized segments of both the vein and artery have been encircled by cotton tapes and elevated by upward traction on the tapes The one tributary inferiorly that was not ligated was particularly large and had a branch tributary that coursed cephalad beneath the renal artery The site of origin and name of this vein and its tributary were both undetermined.

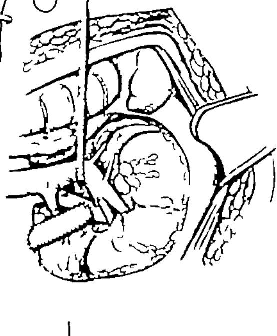
E. Inset shows the dacron prosthesis preparatory to its insertion. The extremity of the graft that is to be anastomosed to the aorta is cut at a 45° angle to facilitate its proper alignment between the aorta and the renal artery

Plate 164









AORTORENAL BYPASS GRAFT

A. The patient is placed in the supine position *and the left paraumbilical incision is indi*cated by the solid black line.

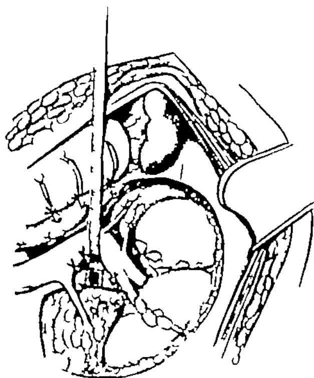
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C. The mobilized portion of the colon is retracted to the right, and the retroperitoneal structures are exposed. The left renal vein is anterior to and obscures almost completely the left renal artery. Its relation to the kidney and the adrenal gland is clearly visible. In this patient there was a multiplicity of renal vein tributaries, which were too numerous to name. Superiorly there were two adrenal veins. Inferiorly instead of one internal spermatic vein, there were four tributaries. The posterior location of *the renal artery and the multiplicity of the* renal tributaries made the exposure of the artery somewhat difficult.

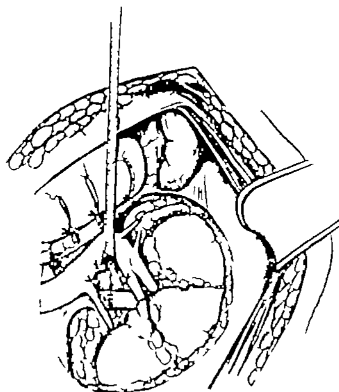
D. The adrenal tributary vein (or veins) is routinely preserved. Three of the tributaries inferiorly were doubly ligated in continuity and severed. The mobilized segments of both the vein and artery have been encircled by cotton tapes and elevated by upward traction on the tapes. The one tributary inferiorly that was not ligated was particularly large and had a branch tributary that coursed cephalad beneath the renal artery. The site of origin and name of this vein and its tributary were both undetermined.

E. Inset shows the dacron prosthesis preparatory to its insertion. The extremity of the graft that is to be anastomosed to the aorta is cut at a 45° angle to facilitate its proper alignment between the aorta and the renal artery.

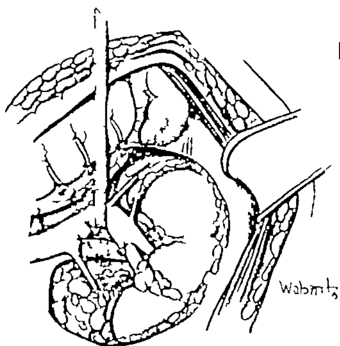
Plate 165



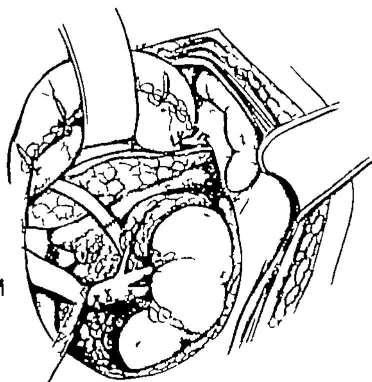
J



K



L



M

F The branch tributary beneath the renal artery is ligated and severed, and the left renal vein is elevated by upward traction on the cotton tape A segment of the aorta is occluded in a Beck Potts clamp which is applied tangentially to its longitudinal axis An opening is made into the lumen of the occluded segment and a suture of 00000 silk is inserted in each angle of the graft and the host aorta, respectively The lowermost angle suture is tied, and the uppermost suture is inserted but untied

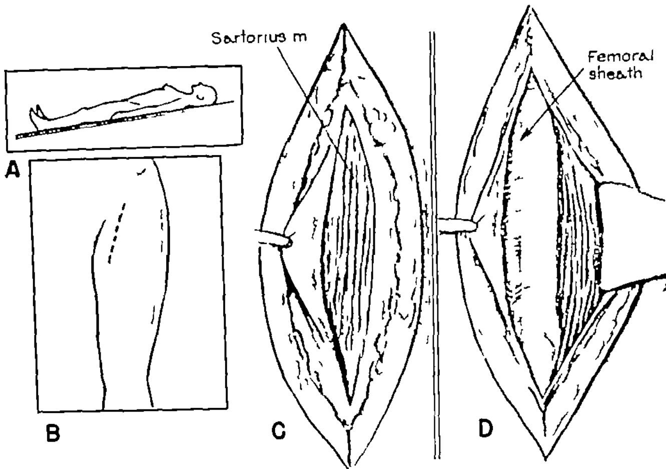
G, H. The needle strand segment of the suture cephalad (a) is continued caudad as a simple over-and-over suture (G) and at its termination at the lower angle it is tied to the needle free strand (b) of the opposing suture (H) The needle strand of the suture in the lower angle (b) is similarly inserted as an over and-over suture which is to be tied to the needle free strand (a') at the upper angle. The suture strands may be seen within the lumen of the anastomosis. The purported disadvantage of this has proved more theoretical than real

I. The insertion of the graft between the side of the aorta and the side of the left renal artery is completed and the relation of the graft to the surrounding structures may be clearly seen

DISCUSSION—DR PAUL T DE CAMP The dissection (C D) illustrates numerous inferior branches of the left renal vein Branches are common in this area and dissection must be meticulous to avoid annoying hemorrhage.

In view of the relatively poor long-term results from plastic prostheses used in the reconstruction of the arteries in the thigh that are of a size comparable to the renal artery I prefer autogenous saphenous vein grafts for aortorenal bypass Only time will tell whether the slight additional effort involved is worthwhile. Vein grafts have the additional advantages of flexibility and adaptability so that kinking is less likely to occur which is a matter of some importance in such a vital area and to an organ as mobile as the kidney

The technic of graft insertion is well illustrated (F I) I prefer to make the more critical, and to me technically more difficult, renal arterial anastomosis first. Circulation is then permitted to resume through the renal artery while the aortic anastomosis is performed This preference may be dictated by my use of the anterior approach If a vein graft is used it is technically easier to place the sutures through the arterial wall rather than through the graft first, which is the preferred technic with a plastic prosthesis.



Fem v
Fem a.
E

Femoral sheath
Common Femoral a.
Common Femoral v.
Profunda femoris
Sup femoral V
F

SEGMENTAL RESECTION OF THE RENAL ARTERY AND PRIMARY ANASTOMOSIS SPLENORENAL ARTERIAL ANASTOMOSIS

J The left renal vein, encircled by a cotton tape is elevated to show the site of segmental blockage of the renal artery The broken lines indicate the boundaries for transection of the renal artery

K. On completion of the segmental resection of the renal artery continuity is restored by end-to-end anastomosis using two continuous sutures of 00000 silk swedged on small minimum trauma needles.

L. This illustration depicts the use of a dacron patch graft (angioplasty) following segmental renal thromboendarterectomy This has proved a most useful technic in the smaller artery as a prophylaxis to a decrease in the size of the lumen

M. The splenic artery is used to revascularize the kidney The use of this technic, first described by Hurwitt and subsequently employed by others, is particularly adapted to renal arterial obstruction (stippled area) to the left kidney The left renal vein is retracted downward and the mobilized greater curvature of the stomach upward to show the site of the end to-end splenorenal arterial anastomosis in relation to the surrounding structures.

DISCUSSION—DR. PAUL T DE CAMP In this condition certain operative diagnostic procedures are as much the responsibility of the surgeon as are therapeutic maneuvers. It is not as yet clear what renal hemodynamic changes are essential to renal arterial insufficiency (or renovascular hypertension) but one must at least determine whether significant hemodynamic changes are present The simplest, and most reliable observation is the intra-arterial pressure proximal and distal to the stenosis. Provided reliable equipment is available, the renal arterial blood flow is also significant. One or both of these parameters should be determined in every case.

Furthermore the surgeon must determine whether *othe* lesions are present which may cause hypertension or affect renal function. With routine bilateral wedge renal biopsies in proved cases of renal arterial insufficiency I have found nephrosclerosis in 79 per cent of the cases, while in 43 per cent of all cases the grade has been moderately severe to severe Pyelonephritis, generally of lesser severity has been found in 50 per cent of the cases. Findings of this type may significantly affect the prognosis and permit a more intelligent appraisal of the subsequent course of the patient.

Operative diagnostic observations should include careful palpation of both kidneys and adrenals, careful palpation, inspection and pressure determinations in both renal arteries, and open wedge biopsies of representative areas of both kidneys

It is chiefly for these reasons that my approach differs from that described, and is the same regardless of the side of the primary lesion. My incision is midline extending to the xyphoid. The transverse colon is lifted out at the upper angle of the wound, and the small bowel is eviscerated into a plastic bag. The ligament of Treitz is divided and the distal duodenum freely mobilized, which provides access to both renal arteries The kidneys may be biopsied directly through this approach or through a more lateral short posterior peritoneal incision.

Alternatively a curved transverse abdominal incision may be employed. With either the midline or the transverse abdominal incision either kidney and its vessels may be approached by a paracolic dissection as illustrated.

Discussion of Segmental Resection of Renal Artery and Primary Anastomosis, Renal Arterial Patch Angioplasty Splenorenal Arterial Anastomosis Occasionally areas of stenosis may be excised with direct reanastomosis of the artery This is a very satisfactory procedure when possible. Stenosis of the suture line is avoided by oblique incisions and interrupted sutures.

In cases of left renal arterial stenosis the splenic artery may be employed as a bypass graft if it is not itself diseased. It is more useful in younger individuals without arteriosclerosis. With the transverse colon lifted up out of the wound, the body of the pancreas rotates forward in the transverse mesocolon, and the splenic vessels may be readily exposed posterior to the cephalad margin of the pancreas. A segment of the artery is cleared, and the vessel is divided An end-to-side splenorenal anastomosis is performed The spleen is not disturbed I have experienced no difficulty with stenosis of this suture line and see no need to perform the technically more difficult side-to-side anastomosis.

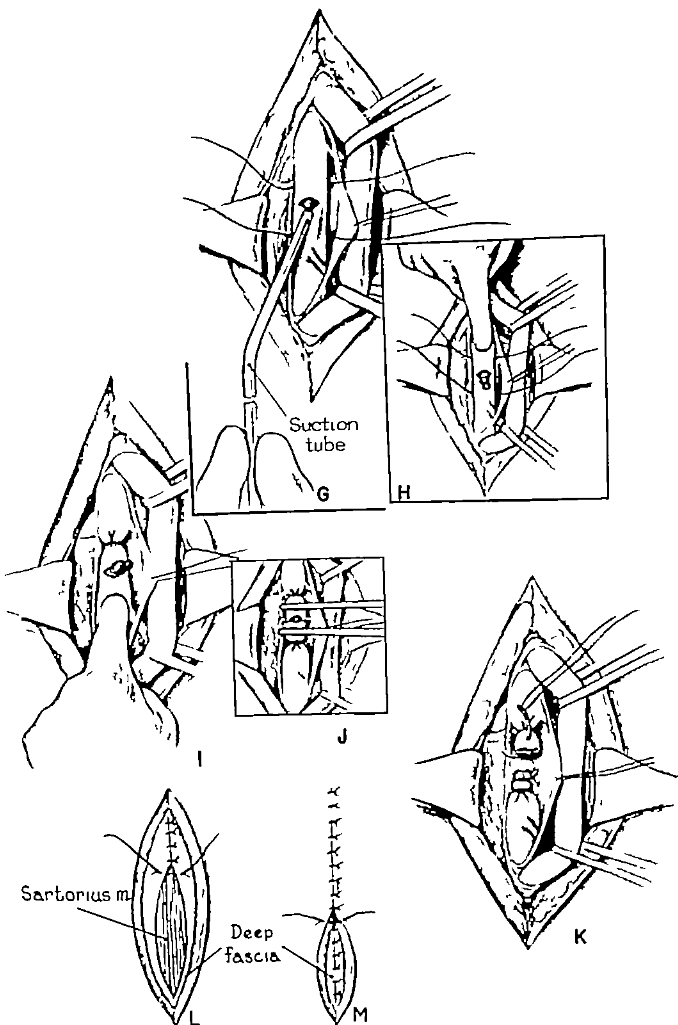
I have been unfavorably impressed by attempts to reimplant renal arteries into the aorta. This procedure may be complicated by sclerosis of the aortic wall and/or by tension incident to a short remaining renal arterial segment

Although bypass grafts may be satisfactorily inserted into the primary bifurcation of the renal artery a word of caution is expressed concerning overly extending the indications for reconstruction to small reduplicated or to segmental arteries, as the danger of technical failure is great

Sometimes the distal arterial "runoff" is inadequate and preoperative arteriographic evidence of this may be lacking because of inadequate visualization of these vessels Careful operative evaluation of the "runoff" vessels is then imperative. There is, furthermore, no point in arterial reconstruction if the renal tissue served is destroyed The renal biopsy may assist in making this decision.

Under marginal circumstances it is wiser not to attempt arterial reconstruction, but to remove the renal tissue served by the diseased vessel, provided that sufficient renal function may be maintained.

Plate 167



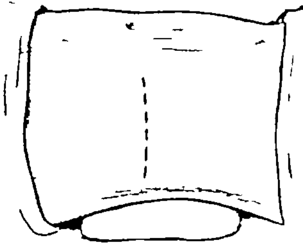
LIGATION OF THE SUPERFICIAL FEMORAL VEIN

A B. The patient is placed in a 10- to 15 degree semi Fowler s position (A) The site of the incision in the upper third of the thigh overlying Scarpa s triangle is indicated in dotted outline (B).

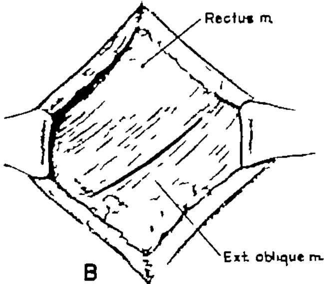
C, D The incision is deepened through the underlying subcutaneous fat and deep fascia (C) to expose the medial border of the sartorius muscle, which is retracted laterally to demonstrate the proximal portion of the femoral sheath and the enclosed femoral artery and vein (D) The characteristic anatomic feature of the common femoral sheath is that the encased vessels are each enclosed by their own respective sheaths, which are demonstrable in the succeeding illustrations (E, F)

E. The common femoral sheath is opened, and the mobilized portion of the femoral artery is encircled with a cotton tape and retracted laterally The separate sheath encasing the femoral vein is incised and the lateral cut margin is secured in a guy suture (000 silk) for traction preparatory to the mobilization of the underlying femoral vein.

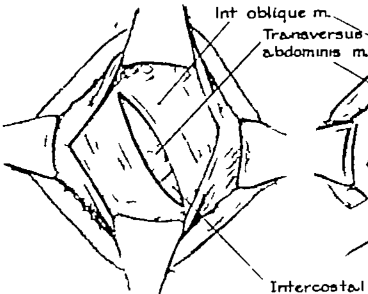
F The femoral artery is encircled by two cotton tapes and retracted laterally In this regard caution must be observed to avoid excessive tension and angulation of the artery because of the danger of producing arterial spasm and secondary stasis thrombosis. In fact, the traction force and angulation of the artery depicted in the illustration is unwarranted and should not be practiced. The superficial femoral vein is mobilized and partially encircled by two ligatures of silk (00) The dotted line between the ligatures indicates the site of the opening to be made in the anterior wall of the vein by scissor dissection The clot within the lumen of the vein is depicted by the dark shadow extending cephalad to the level of entrance of the profunda femoris tributary



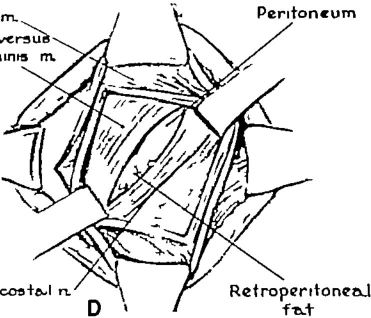
A


Rectus m.
Ext. oblique m.

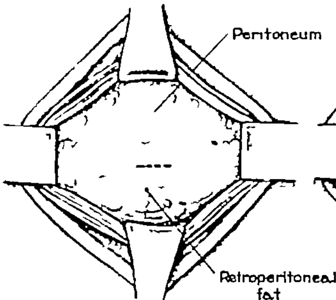
B


Int oblique m.
Transversus abdominis m.
Intercostal n.

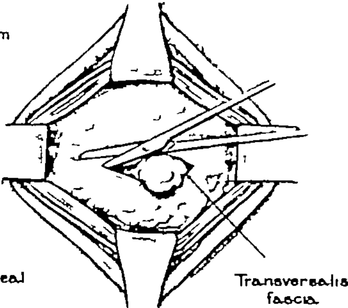
C


Peritoneum
Retroperitoneal fat

D


Peritoneum
Retroperitoneal fat

E


Transversalis fascia

F

G. The incision in the superficial femoral vein is completed, and the partially extruded clot is being aspirated by suction

H, I, J By digital retrograde "milking," more of the clot is extruded through the phlebotomy site (H) and when the cephalad evacuation of the clot is completed, the upper encircling ligature of silk (00) is tied (I) Similarly by digital "milking," the clot, caudad in the lumen of the vessel, is evacuated (I), and the lower encircling ligature is tied (J) The superficial femoral vein is doubly clamped between the ligatures, and the transection of the vein at the site of the phlebotomy is completed as indicated by the dotted line (J)

K. The distal transected end of the superficial femoral vein is further occluded with a suture ligature of silk (000) and its proximal transected end is being similarly occluded. For clarity the clamp has been removed from the proximal transected end as the suture ligature is being inserted.

L, M. The deep fascia (L) and skin (M) are closed with interrupted sutures of 000 silk to complete the operation

DISCUSSION—DR. W G ANLYAN First and foremost I do not believe in interrupting the superficial femoral vein following thrombectomy Instead, at our clinic we have closed the venotomy incision and repaired the vein leaving its continuity intact.

The position we have used has been the supine position rather than the reverse Trendelenberg, and no embolic phenomena that have been recognized have occurred in the course of this procedure.

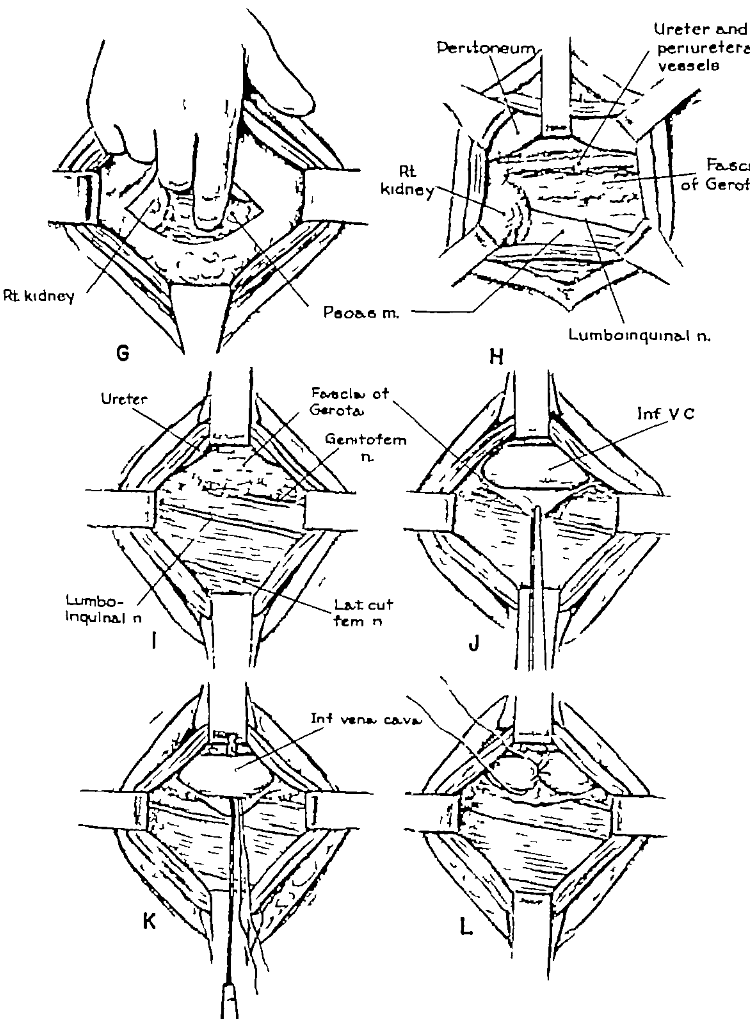
In the exposure of the vessel the artery may be left completely intact and should not be retracted. The saphenofemoral junction has been the principal site of selection for our venotomy incision.

To aid in the evacuation of a clot after opening the venotomy incision, we have milked the extremity starting just above the malleoli and working upward with a snug circumferential roll of stockinette. While this is being done, care must be taken to ensure that the proximal femoral vein is completely occluded by the cotton tape. At times this milking maneuver has produced a very long clot, which has been a cast of the deep venous system.

After completing the milking procedure a soft plastic catheter is introduced proximally and connected to gentle suction while it is being advanced proximally to suction out all the clot in the proximal common femoral vein and external iliac vein. After securing brisk bleeding both proximally and distally the vein is irrigated with heparinized saline and the venotomy incision closed with 00000 arterial silk. We prefer to do this procedure under unilateral spinal anesthesia, but it can be done equally readily under local anesthesia.

Usually 50 mg. of heparin is administered intravenously immediately following the induction of the spinal anesthetic and before the skin incision is made. The patient is maintained on heparin postoperatively by the subcutaneous route.

Following the operation the patient is kept in the Trendelenburg position.


Rt. kidney
Psoas m.
G
Peritoneum
Ureter and periureteral vessels
Rt. kidney
Fascia of Gerota
Lumboinquinal n.
H
Ureter
Fascia of Gerota
Genitofem n.
Lumbo-inquinal n
Lat. cut fem n
I
Inf V C
J
Inf vena cava
K
L

LIGATION OF THE INFERIOR VENA CAVA

A. The patient is placed in the supine position, and the right side is elevated to approximately a 25 degree angle from the horizontal The incision extends transversely from the lateral border of the rectus muscle at the level of the umbilicus outward to the midaxillary line just beneath *the costal margin, as indicated in dotted* outline

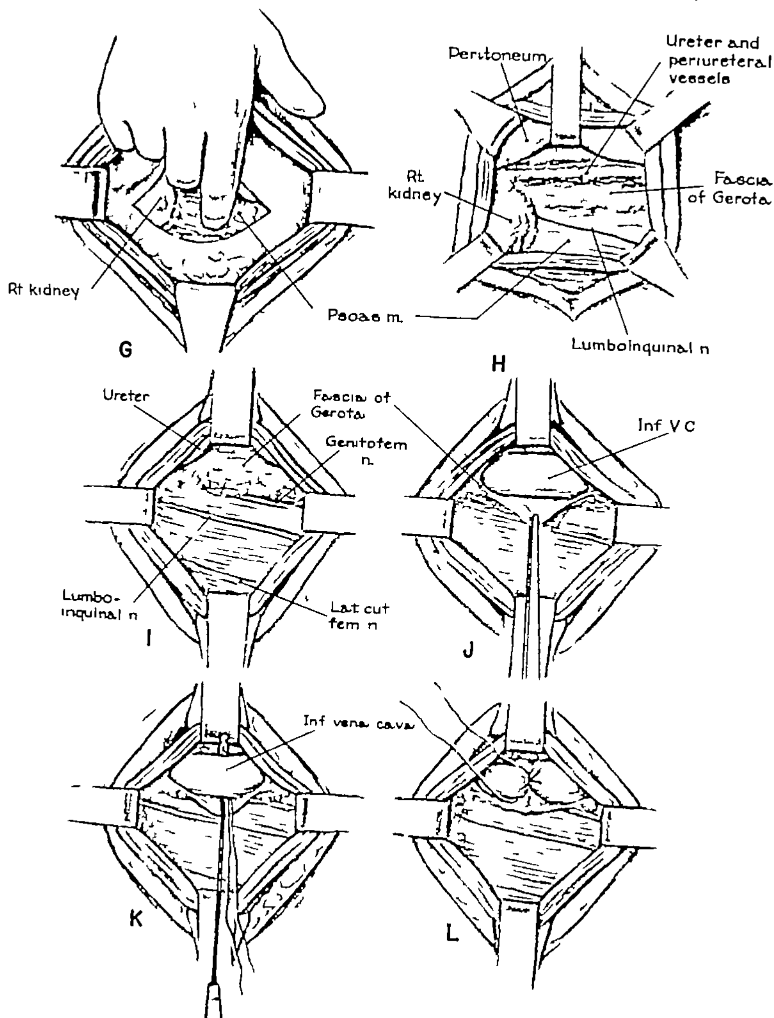
B. The upper and lower skin flaps are dissected immediately beneath the subcutaneous tissue plane and retracted to expose a large surface area of the external oblique muscle and the line of separation of its fibers A portion of the rectus sheath is also visible

C. The separated margins of the external oblique muscle are retracted to expose the fibers of the internal oblique, which is the thickest of the three muscles to be separated Through the line of separation of the fibers of the internal oblique, the underlying transversus abdominis muscle and one of the intercostal nerves are visible

D The transversus abdominis muscle is separated in the direction of its fibers, and the irregular line of apposition of the retroperitoneal fat with the peritoneum is visible. *The dissection of this muscle the thinnest* of the group is begun laterally and continued medially to lessen the possibility of opening into the peritoneal cavity

E. The muscles of the anterolateral abdominal wall are separated, and the line of apposition of the retroperitoneal fat and peritoneum may now be clearly seen The dotted line indicates the site of incision in the transversalis fascia overlying the retroperitoneal fat.

F The transversalis fascia is incised by scissor dissection and a portion of the retroperitoneal fat is seen to herniate through the opening.


Rt kidney
Psoas m.
G
Peritoneum
Ureter and periureteral vessels
Rt kidney
Fascia of Gerota
Lumboinquinal n
H
Ureter
Fascia of Gerota
Genitofem n.
Lumbo-inquinal n
Lat cut fem n
I
Inf VC
J
Inf vena cava
K
L

G H. By blunt digital dissection in the retroperitoneal fatty tissue plane, the peritoneum and the intraperitoneal viscera adjacent are displaced toward the midline During this dissection an important landmark is the psoas major muscle which is located more anteriorly than one generally assumes. The tissue dissection is continued anterior and medial to this muscle other wise, troublesome technical difficulties may ensue. When the dissection is completed to the vertebral column, blunt digital dissec tion is continued, first cephalad and then caudad in the same plane A wide type Harrington retractor is used to maintain re traction of the peritoneum and the encased adjacent viscera. The right ureter is then identified as it courses along in the fatty tissue plane on the anterior surface of the inferior vena cava.

I. The right ureter is retracted from the an terior surface of the vena cava, and the line of incision in the overlying fibroareolar tissue layer (fascia of Gerota) is depicted

J The inferior vena cava is exposed preliminary to the completion of the mobilization of its circumference at the level selected for ligation. In the isolation and mobilization of the inferior vena cava a medium sized "kidney pedicle" clamp and a malleable ligature carrier* with a ball-point protected tip are the instruments that have proved the most useful Medially the vena cava is in timately adherent to the adjacent tissues, and the lumbar veins enter posteromedially Accordingly during the dissection and mobilization posteriorly and medially one must be careful to avoid either an avulsion tear of one of the lumbar veins or an in advertent perforation of the vena cava. Should either occur bleeding is best con trolled by immediate compression of the vena cava with "stick" sponges both prox imal and distal to the site of hemorrhage. Hemostasis may then be obtained by closure of the opening with sutures of fine silk (00000) swedged on a minimum trauma needle.

K L. The mobilized segment of the vena cava is encircled with two ligatures of braided silk (No 1) using a malleable lig ature carrier and a double ligation in con tinuity is performed

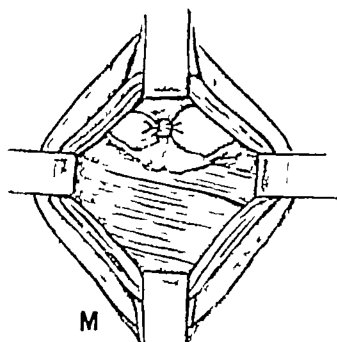
* Manufactured by Edward Weck & Co Inc., Brooklyn, N Y

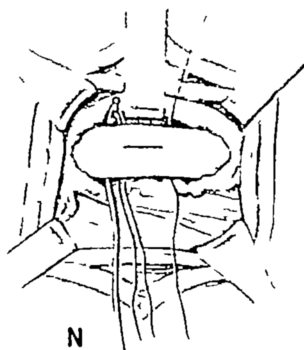
Discussion—Dr. Jere W Lord During the decade from January 1 1948, through December 31 1957 on the surgical services of the Fourth Division, Belle vue Hospital, the University Hospital, and in this commentator s private practice, only two patients were subjected to ligation of the inferior vena cava. The vast majority of the patients with thromboemboli were treated with anticoagulants In fact, only 10 patients were operated upon. In six of these, ligation of the superficial femoral vein was performed In two of the remaining four one had a ligation of the superficial femoral vein and the other had a ligation of the right common iliac vein. In the remain ing two, ligation of the inferior vena cava was done At operation, when palpation revealed thrombotic material, the vein was opened, aspirated both prox imally and distally and then doubly ligated in continuity

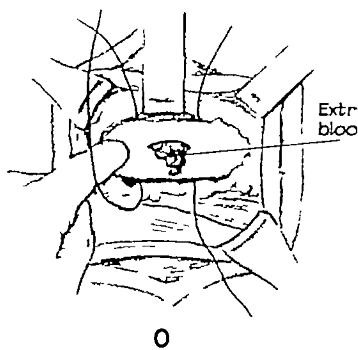
Although the author's personal experience has been most favorable with ligation of the inferior vena cava, several papers in the literature have em phasized the serious late sequelae of ulceration, edema, and recurrent phlebitis We have observed these complications in three patients in whom ligation of the inferior vena cava was performed on the Fourth Surgical Division of Bellevue Hospital be tween 1944 and 1948.

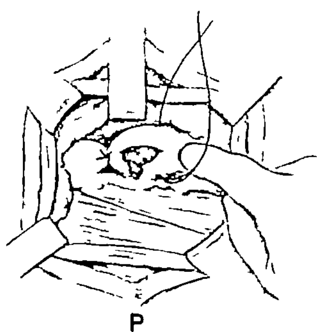
In the postoperative management of the patient following ligation of the superficial femoral vein or ligation of the inferior vena cava, the important fac tors which should be stressed are: (1) the wearing of custom-made elastic stockings for prolonged pe riods to control the edema of the legs (2) elevation of the foot of the bed on blocks (10 inches) and (3) the adherence to strict hygienic measures in the care of the feet to avoid a fungus infection. In some patients the wearing of an elastic support may be discontinued within six to eight months, whereas, in others, it may be necessary to continue the use of elastic supports for the remainder of their lives.

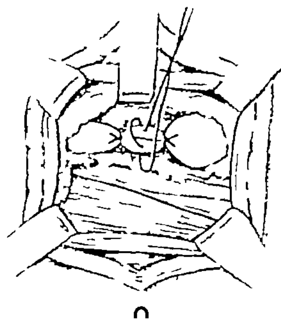
In regard to surgical technic the artist s illustra tions are clear and the accompanying text is entirely adequate The use of "stick" sponges for the control of bleeding from torn lumbar veins is considered the best method for hemostasis. The sponges are held in place for 8 to 10 minutes to allow the for mation of a blood clot to block the bleeding point. The venous pressure in the inferior vena cava is usu ally low and may be lowered still further by depressing the head of the table (Trendelenburg position). Clamps should rarely be applied to the vena cava If bleeding persists, it should be controlled either by the use of silver (dural or Cushing) clips or transfixion sutures of fine silk (00000) swedged on a minimum trauma needle


M


N


Extr
bloo
O


P



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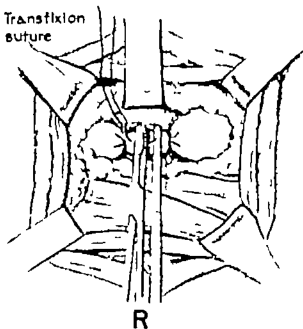
Manufactured by Edward Weck & Co Inc., Brooklyn, N Y

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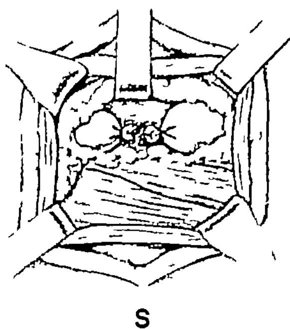
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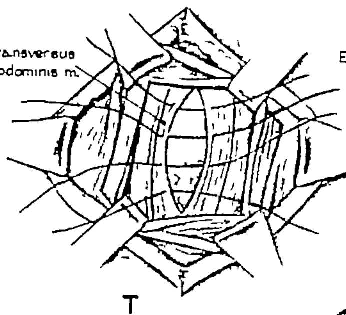
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Transfixion suture

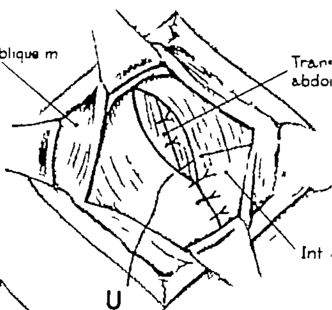
R



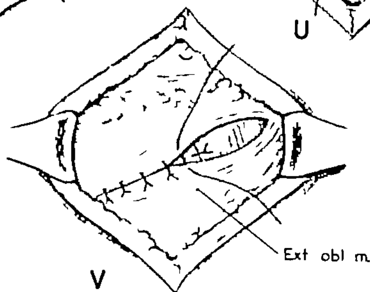
S


Transversus abdominis m.

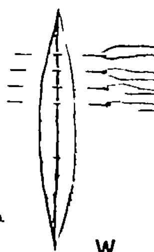
T


Ext oblique m

U


Ext obl m.

V

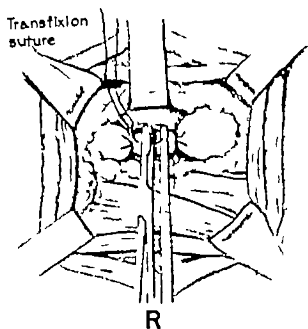


W

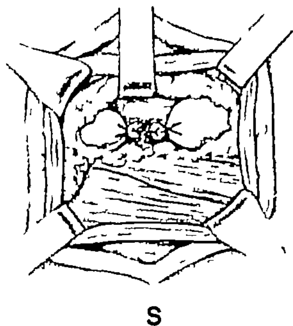
M. The operative field after completion of the double ligation in continuity of the inferior vena cava is shown.

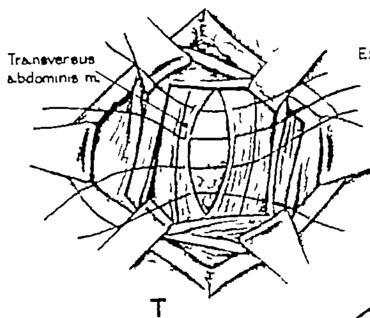
N O P Q These illustrations depict the technic that is employed when a thrombotic occlusion of the lumen of the inferior vena cava, commonly associated with phlegmasia cerulea dolens is present. The vena cava is incised between the encircling but untied ligatures of silk (No 1) and the thrombus is evacuated (O) This is done by digital compression first from above downward until free retrograde bleeding from the renal veins occurs The proximal ligature is then tied (P) The thrombus is next evacuated from below upward and the distal ligature is tied (P) If desired an additional suture of the transfixion type may be inserted between the ligatures as indicated (Q)

Plate 171

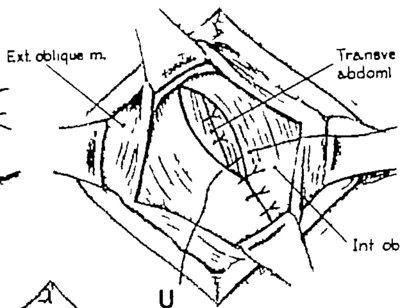


R

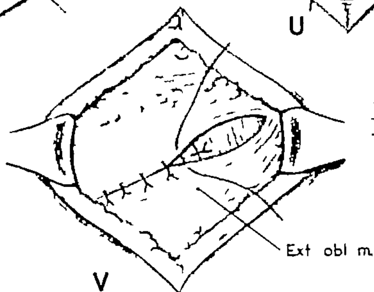

S



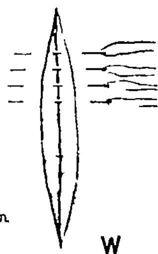
T



U



V


W

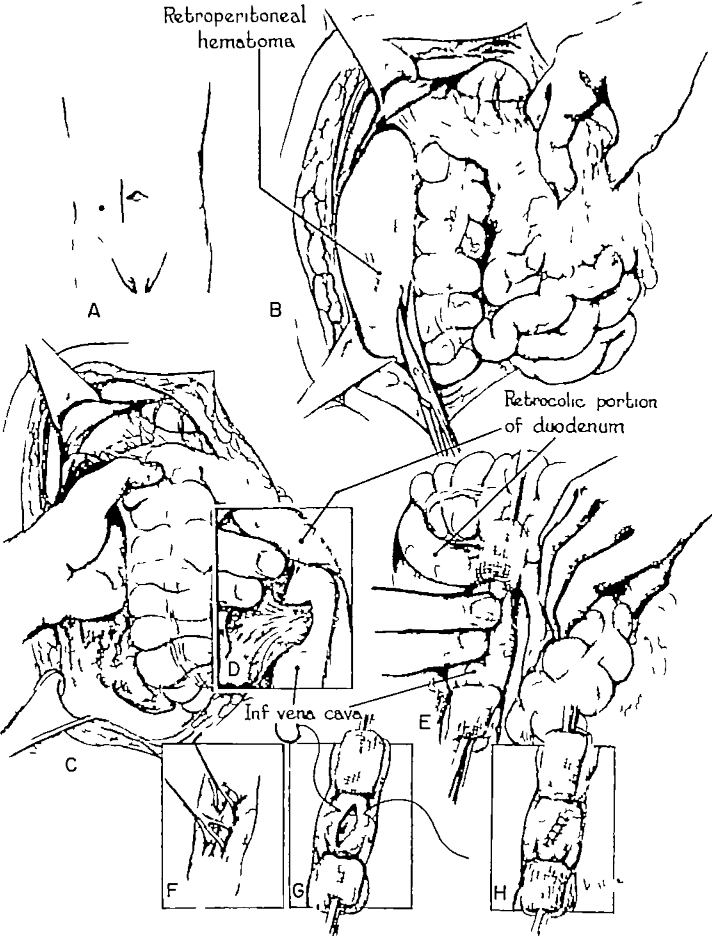
R S. These illustrations depict an alternate but less desirable method of transection of the vena cava. This is done between clamps following double ligation in continuity. The severed ends are occluded with transfixion sutures of silk as the clamps are removed.

T The retractors in the retroperitoneal tissue plane have been removed and the overlying muscle layers of the anterolateral abdominal wall tend to approximate themselves. The line of apposition of the retroperitoneal fat and peritoneum is visible beneath the incompletely approximated fibers of the transversus abdominis muscle. The adjacent intercostal nerve may also be seen.

U V W The closure of the remainder of the muscle layers and the skin, using interrupted sutures of silk (000), is depicted.

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We prefer to tie the vena cava at the most convenient level above the highest point of thrombus formation that is palpable, and we do not routinely try to go up to the level just below the renal veins. We have not attempted any plication occlusions of the vena cava, since most of our patients have repeated small pulmonary emboli as the main indication for ligation rather than a single massive one. Division of the vena cava is unnecessary and complicates the procedure.


Retroperitoneal hematoma
A
B
Retrocolic portion of duodenum
C
D
Inf vena cava
E
F
G
H

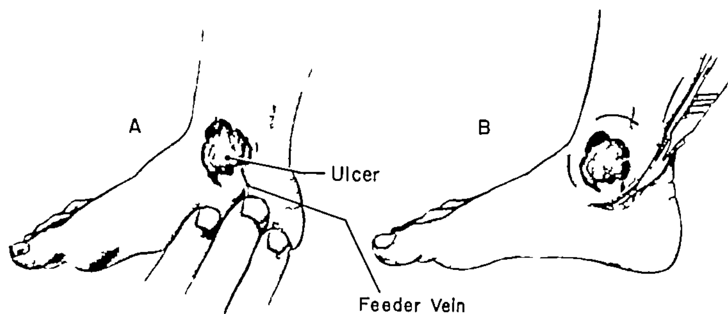
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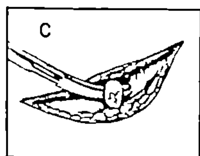
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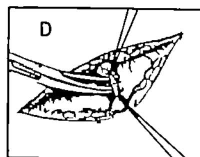
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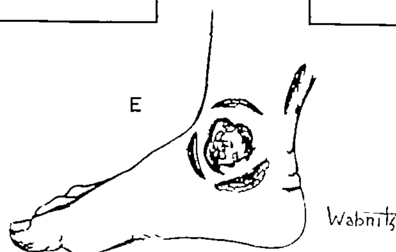
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A
B
Ulcer
Feeder Vein


C


D


E
Wabnitz

REPAIR OF TRAUMATIC LACERATION OF THE INFERIOR VENA CAVA

The patient, a 39-year-old police officer shot by an assailant, was admitted to the hospital in shock Examination revealed a bullet wound of entrance below and to the right of the umbilicus and a wound of exit in the right loin. Replacement of blood loss and operation were done concomitantly There were two perforations in the small bowel and a large retroperitoneal hematoma on the right side The perforations were temporarily occluded with clamps, and the large retroperitoneal hematoma was evacuated. The lacerated wound of the inferior vena cava was repaired as illustrated, and the intestinal wounds were closed in layers (2) The postoperative convalescence of the patient was uneventful.

A. The patient is in the supine position, and the right paraumbilical incision is outlined. The bullet wound of entrance is indicated by the black circle.

B. The peritoneal cavity is entered, and the bulging retroperitoneal hematoma is visible Mobilization of the right colon is begun by scissor dissection along the fascia fusion layer of Toldt, the "white line"

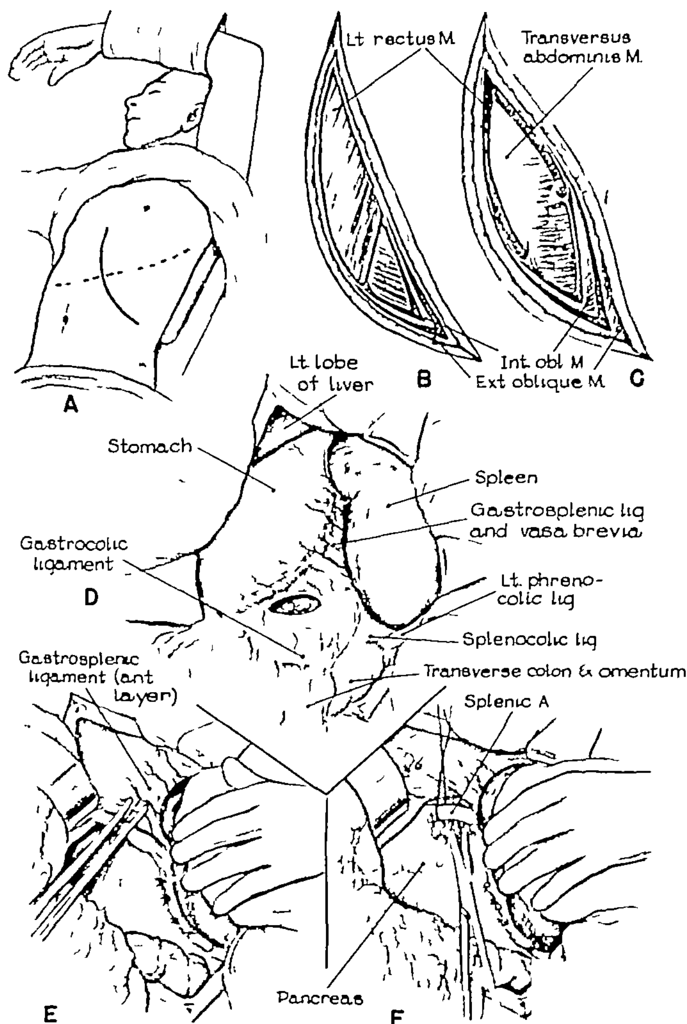
C. Mobilization of the right colon is continued by digital dissection. The subsequent severance of the phrenocolic ligament to free the hepatic flexure is indicated by the broken line cephalad. The clotted blood retroperitoneally (caudad) is also visible

D E, F Following decompression of the retroperitoneal space by the evacuation of large quantities of clotted blood, active bleeding from the traumatic laceration in the inferior vena cava ensued (D) The bleeding was immediately controlled by digital compression (E) The "blind" application of clamps for hemostasis is dangerous and should be judiciously avoided Large pledgets of dry gauze secured in clamps, are used to compress the inferior vena cava both cephalad and caudad to the site of digital compression The fingers are removed, and the margins of the laceration in the inferior vena cava are approximated with clamps * (Babcock) modified on the Potts principle (F)

G, H. Gauze compression of the inferior vena cava is maintained as the clamps are removed (G) and the lacerated wound is closed using interrupted sutures of 00000 arterial silk (G H)

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* Manufactured by Edward Weck & Co., Long Island City N Y


Lt rectus M
Transversus abdominis M.
Int. obl M
Ext oblique M
A
B
C
Lt lobe of liver
Stomach
Spleen
Gastrosplenic lig and vasa brevia
Gastrocolic ligament
D
Lt. phreno-colic lig
Splenocolic lig
Gastrosplenic ligament (ant layer)
Transverse colon & omentum
Splenic A
Pancreas
E
F

CIRCUMFERENTIAL VENOUS LIGATION FOR POSTPHLEBITIC ULCER

A. Palpation of a "feeder" vein subjacent to the ulcer

B. The incisions in relation to the ulcer are shown and the lowermost is being deepened through the underlying indurated tissue.

C. The "feeder" vein is isolated

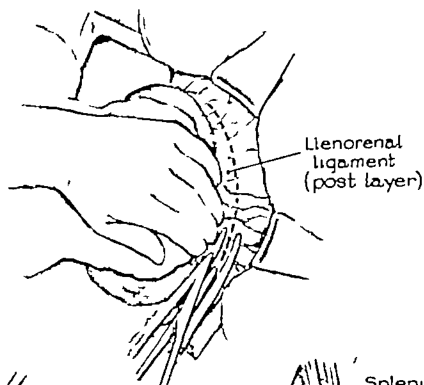
D It is doubly ligated in continuity and severed.

E. The operation is completed. The wounds, rather than being sutured, are packed loosely with sterile dry gauze and a compression dressing is applied.

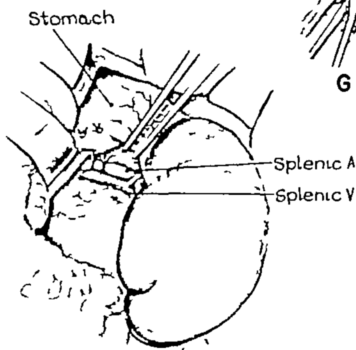
DISCUSSION—DR. JOHN L. KEELEY The operation described by Dr Madden appears to offer a promising solution for a very troublesome lesion. His results justify its further trial as it is a procedure that in the past has not been as helpful in the hands of others. If an ulcer such as that illustrated is dependent upon venous stasis alone, interruptions of the neighboring veins as described should be beneficial However many will be associated with postphlebitic induration in the surrounding blood-poor tissues, such as fat, ligaments, tendons, and periosteum In patients with normal tissues healing is slower in the region of the ankle than at higher levels. This is well illustrated in the healing of incisions at the ankle level compared to those which take place at higher levels in the ligation and stripping of varicose veins uncomplicated by previous cellulitis. The ankle is near the end of the "blood supply line." If arteriosclerosis is also present, one hesitates to cut off blood supply coming to an ulcerated area through vessels in the skin or immediately under it by partially surrounding the ulcer with incisions. Patients with either ulcer or postphlebitic induration should be warned of the vulnerable status of tissues in the areas so characteristically involved. Trauma to the region, whether surgical or accidental, may be followed by ulceration or slow healing.

One wonders if the postoperative care following circumferential venous ligation is more carefully planned and executed than that ordinarily accorded the patient with an ulcer not subjected to a surgical procedure Attention paid to cleanliness and asepsis and to effective support for the area may contribute significantly to the good results the author has attained

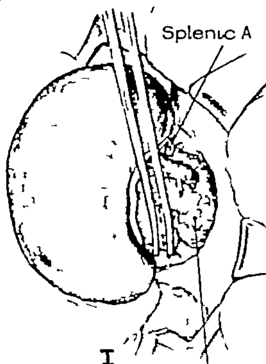
It seems reasonable that the patient with an ulcer about which "feeder" veins may be demonstrated and with minimal evidence of postphlebitic cellulitis might be treated by this procedure on a trial basis In some patients it may suffice. If it fails, the more formidable operations of fasciectomy and individual ligation of perforating communicating veins, with or without skin grafting, may be needed.


Llenorenal ligament (post layer)

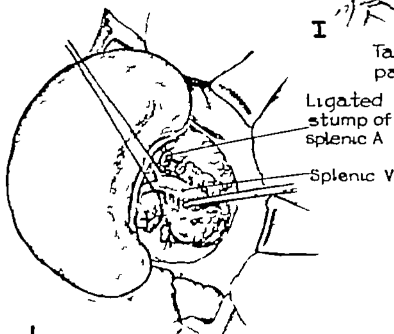
G


Stomach
Splenic A
Splenic V

H


Splenic A
Tail of pancreas

I


Ligated stump of splenic A
Splenic V

J

SPLENECTOMY AND END TO SIDE SPLENORENAL SHUNT

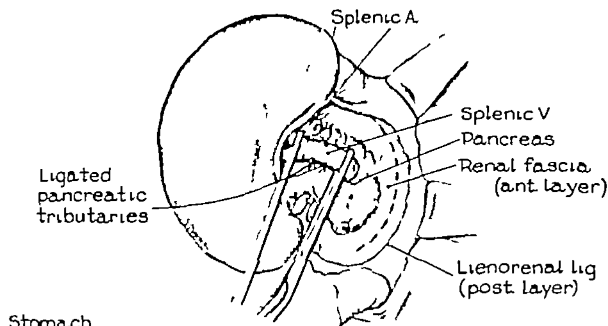
A. The patient is placed in the supine position, and the left side is elevated on a pillow support to approximately a 30 degree angle from the horizontal The incisions of choice, a long curvilinear subcostal incision solid line) that extends from the left costophrenic angle to the posterior axillary line, and an abdominothoracic incision (dotted outline) that enters the left pleural cavity through the eighth interspace, are shown. In this particular patient, the subcostal incision was used.

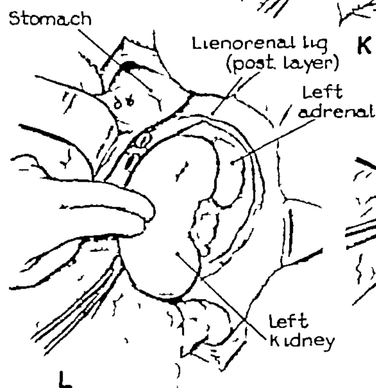
B C. The incision is deepened through the rectus sheath, the underlying fibers of the rectus abdominis, the external oblique, and the internal oblique muscles to expose the transversus abdominis muscle and its aponeurosis.

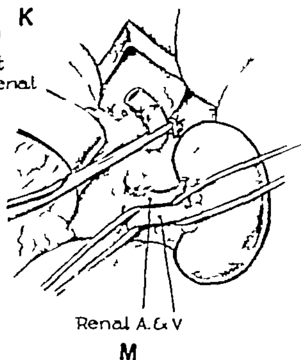
D The peritoneal cavity is entered, and the relation of the enlarged spleen to the surrounding structures is depicted. An opening is made in an avascular segment of the gastrocolic ligament preliminary to the serial clamping and severance of its proximal extension, the anterior layer of the gastrosplenic ligament.

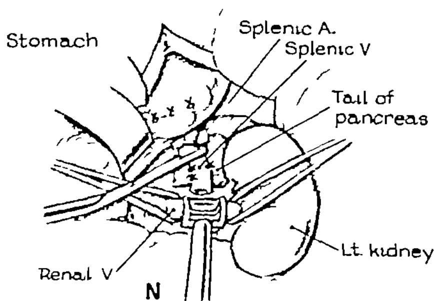
E. The mobilization of the spleen is continued by doubly clamping and cutting (dotted line) the anterior layer of the gastrosplenic ligament and its contained vasa brevia.

F The superior border of the pancreas is exposed, and the splenic artery is encircled by a ligature of silk (00) for traction as mobilization of the artery is completed by scissor dissection. A second ligature of silk (00) is subsequently inserted, and double ligation, in continuity of the splenic artery is performed.


Splenic A.
Splenic V
Pancreas
Renal fascia (ant. layer)
Ligated pancreatic tributaries
Lienorenal lig (post. layer)
K


Stomach
Lienorenal lig (post. layer)
Left adrenal
Left Kidney
L


Renal A. & V
M


Stomach
Splenic A.
Splenic V
Tail of pancreas
Lt. kidney
Renal V
N

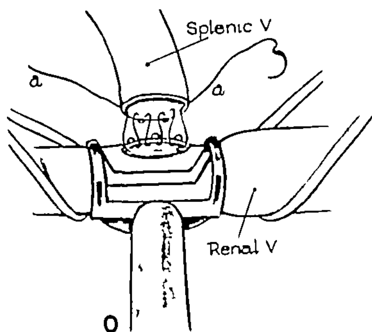
G The spleen is manually rotated and displaced toward the midline, and the reflection of the posterior parietal peritoneum forming the posterior layer of the lienorenal ligament is severed under direct vision by scissor dissection Normally this ligament is avascular However in the presence of portal hypertension the application of clamps to this ligament is frequently required to prevent excessive blood loss from the extensive collateral vascular bed.

H. The spleen is reposited laterally and the superior segment of the gastrocolic ligament is doubly clamped and severed (dotted line). This segment is the narrowest portion of the gastrosplenic ligament, and particular care should be observed in the application of clamps to prevent injury to the greater curvature of the stomach Furthermore, one of the largest of the vasa brevia is contained in this narrow uppermost portion of the gastrosplenic ligament in relation to the superior pole of the spleen. Accordingly in the mobilization of the superior pole of the spleen, one should proceed with caution to avoid an avulsion laceration of this vessel and resulting hemorrhage

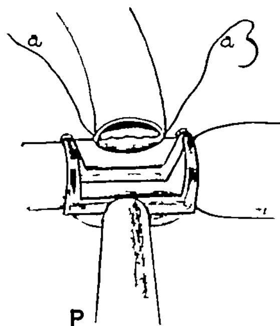
I. Following the completion of the severance of the anterior layer of the gastrosplenic ligament, the spleen is again rotated toward the midline and the pad of vascular areolar tissue in relation to the inferior pole of the spleen and the tail of the pancreas is doubly clamped prior to its severance.

J The splenic vein in the hilum of the spleen is encircled with a traction ligature of silk (00), and the vein is mobilized by clamping and dividing the pancreatic tributary veins as indicated

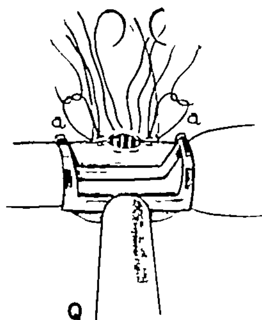
Plate 177



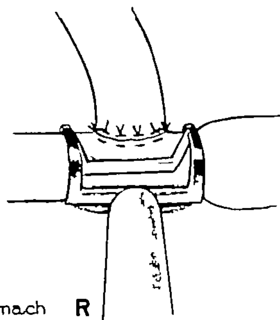
Splenic V
a
a
Renal V
O



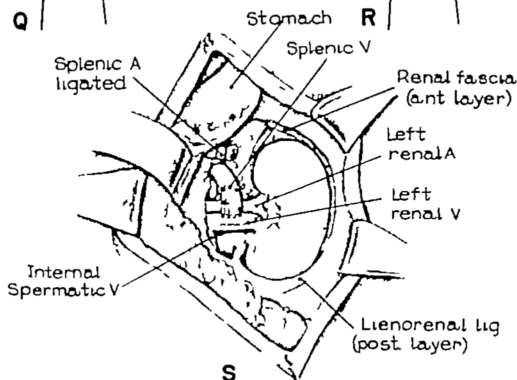
a
a
P



a
a
Q



R



Stomach
Splenic V
Splenic A ligated
Renal fascia (ant layer)
Left renal A
Left renal V
Internal Spermatic V
Lienorenal lig (post layer)
S

K. The mobilized segment of the splenic vein is doubly clamped using both angulated and straight Potts ductus clamps The site for transection of the vein, in juxtaposition to its bifurcation at the hilum of the spleen, is indicated by dotted lines. The incision in the anterior layer of the renal fascia for the exposure and subsequent mobilization of the kidney is also indicated in dotted out line

L. The left kidney is mobilized from its sur rounding adipose capsule and rotated toward the midline The relation of the kidney to the left adrenal gland and the sur rounding structures is visible

M The mobilized kidney is rotated laterally and posteriorly and the distal segments of the renal artery and vein are mobilized by a combination of blunt and sharp dissec tion. The renal vein is encircled by cotton traction tapes to facilitate its manipulation.

N. The lumen of the renal vein is partially oc cluded by a Potts-Smith clamp and the proximal cut end of the splenic vein is turned down toward the incised opening in the renal vein preparatory to the anasto mosis

Discussion—Drs. Arthur H Blakemore and Ar thur B Voorhees, Jr The position of the patient on the operating table, the location and technic of the incision are similar to those described in *Portal vein to-vena cava anastomosis*, with the exception that all takes place on the left rather than the right side of the patient (Fig. 1).

When the operative incision and general abdominal examination have been completed, manometric pressures in the portal system are recorded by the described technic. A liver biopsy is obtained in the described fashion however in this case it is usually obtained from the left lobe rather than the right lobe of the liver

At this point the operation can be divided into three steps for sake of convenience of description. The first step is the mobilization and subsequent resection of the spleen. The second step is the identification and mobilization of the splenic vein, and the third step is the performance of an end to-side anastomosis between the splenic vein and the left renal vein.

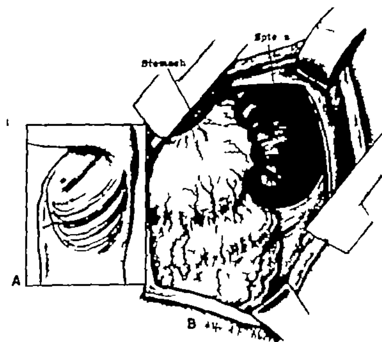


Fig 1 A. line of incision, B. illustrating exposure following completion of a thoracoabdominal approach Note that splitting the diaphragm affords direct access to control of hemorrhage in separating an adherent spleen from the diaphragm

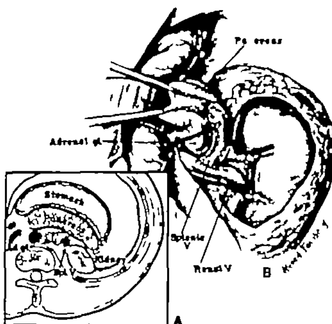


Fig 6 B an illustration of the completed splenorenal shunt. Note in cross-section illustration A that the splenic vein rests in a deep sulcus between the left adrenal gland and the upper pole of the kidney out of harm's way from compression by the pancreas

Discussion—Drs. Blakemore and Voorhees (cont)

tributaries, the left spermatic (or ovarian) vein and the adrenal vein, should be identified and preserved where possible. However if the preservation hampers subsequent anastomosis, both may be ligated with impunity. After clearing the renal vein, the left adrenal gland and its vascular supply are identified, and the adrenal gland is pushed medially by dividing its adventitial attachment to the kidney capsule. By pushing the adrenal gland medially a sulcus can be developed between the adrenal gland and the upper pole of the left kidney which will subsequently accommodate the splenic vein and offer it protection from subsequent compression by the overlying pancreas. We feel that the development of this protected channel is of utmost importance. By trial placements of the splenic vein stump, a suitable site for end to-side anastomosis with the renal vein is selected so that an anastomosis of maximum obliquity between the splenic vein and the renal vein can be achieved. It is desirable that the splenic vein and the renal vein form an acute angle of roughly 60 degrees. After selection of the site of anastomosis, marking stay sutures are placed in the renal vein, and the vein is tented and grasped by a Beck Potts clamp. An end to-side anastomosis is achieved in precisely the same fashion as that described for the portacaval shunt, with the exception that, in children where growth is expected, interrupted horizontal mattress sutures are employed in the anterior row of the anastomosis instead of the continuous over and over everting suture. Following completion of the anastomosis, the clamps are removed and the shunt is carefully examined for deformities which may compromise the efficiency of the shunt. The pancreatic tail is allowed to resume its natural position. Portal pressures are again taken, with and without splenic vein compression, to test the efficiency of the shunt. The splenic flexure of the colon is allowed to fall into place and no effort is made to reperitonize the operative area. The abdominal and thoracic wounds are closed in similar manner to that described for the portal vein to-vena cava shunt.

O, P Q R. Close up illustrations to show more clearly the technic of the anastomosis of the proximal cut end of the splenic vein to the longitudinal opening in the side of the left renal vein.

O P The posterior suture layer is inserted. This is a continuous eversion suture of 00000 arterial silk on a swedged-on minimum trauma needle The suture is commenced from the "outside in" on the splenic vein and terminates from the "inside out" on the same vein. Between its commencement and termination, the suture is inserted alternately from the "inside out" to the "outside in" on the renal and splenic veins respectively Accordingly the loop is on the outside of the lumen, and, when the suture is drawn taut, it causes an eversion of the tissues with intima to intima approximation.

Q The anterior layer of the anastomosis consists of a series of interrupted everting mattress sutures of silk (00000) These sutures are all inserted, and the end sutures are tied. One of the strands of each of the end mattress sutures is then tied to either end of the continuous everting posterior suture (a–a).

R. The completed anterior layer of the anastomosis prior to the release of the Potts-Smith clamp is shown

S. The completed end to-side splenorenal shunt and its relation to the surrounding structures is illustrated

DISCUSSION—DRS. BLAKEMORE AND VOORHEES (cont.)

Step 1 (Figs. 2 and 3) The gastrolienal and lienocolic ligaments are divided. The anterior rim of the spleen is rotated laterally in order to expose the hilar structures. The splenic artery is identified and doubly ligated proximal to its subdivision. The splenic vein is identified and gradually mobilized by sharp dissection to the hilus of the spleen. A rubbershod noncrushing clamp is applied as the splenic vein goes beneath the tail of the pancreas, and a crushing clamp is applied to the splenic vein as it emerges from the hilum. The vein is transected, and the spleen is removed after division of its diaphragmatic attachments.

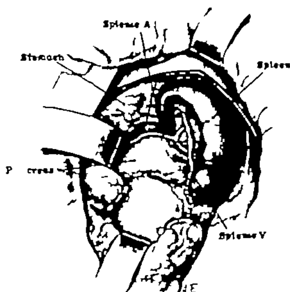


Fig 2 Exposure of short gastric vessels, splenic artery and splenic vein

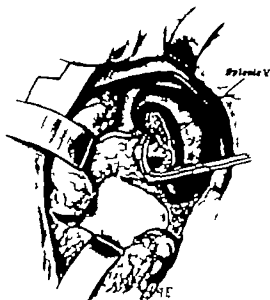


Fig 3 A rubbershod clamp has been placed on the splenic vein, and it is ready for section well distal to the clamp

DISCUSSION—DR. WELCH (cont)

splenic vein is done posteriorly after mobilization of the spleen and rotating it medially I do not believe that this technic can be carried out satisfactorily Mobilization of the splenic vein is best done anteriorly with the spleen in nearly its usual position The splenic vein is actually partially imbedded in the pancreas. Securing all of the small intrapancreatic tributaries is the important feature of this step

L, M N O P Q R, and S deal with mobilization of the kidney and the actual anastomosis of the end of the splenic vein to the side of the renal vein partially occluded in a Potts-Smith clamp This would seem to be a good technique employing the everting suture anastomosis If the renal vein is large an oval opening can be made in the occluded segment This is said to make the anastomosis less "slitlike" and less likely to close. A transverse opening in the renal vein may also be made. It tends to gape and stay open, which lessens the likelihood of anastomotic thrombosis. Such an incision requires that the blood supply to the kidney be occluded during the anastomosis. This is done by putting a bull dog clamp on the renal artery to occlude temporarily its blood supply The actual time needed to complete a splenorenal anastomosis is approximately 20 minutes, which is readily tolerated by the kidney I have used temporary renal artery occlusion during splenorenal anastomosis in many patients without permanent damage to the kidney as judged by post operative intravenous pyelograms. This technique is particularly useful when the application of a clamp to partially occlude the renal vein is difficult and awkward

DISCUSSION—DR. LOUIS M ROUSSELOT Portasystemic shunts are primarily indicated for the relief of gastroesophageal hemorrhage by lowering the portal tension in the syndrome of portal hypertension. Dr Madden s preference is a direct end-to-side portocaval shunt rather than a splenorenal shunt. It is my opinion that a splenorenal shunt be reserved for those cases in which the former is not feasible—i e., an extrahepatic portal vein block, either congenital or acquired.

The incisions illustrated in A represent standard approaches. The combined thoracoabdominal incision *(broken line) gives the optimal exposure* With the combined approach, the abdominal component should be initially opened to confirm the diagnosis and establish operability An unsuspected hepatoma or a secondary malignant disease that obstructs the portal bed may be established, a biopsy taken and the operation terminated forthwith.

In the presence of inflammatory pulmonary disease, the incision should be limited to the abdomen. Besides the subcostal incision shown in A, a long transverse incision from the midline well out to the flank may be substituted.

The operative steps in A through S are clearly illustrated with exactitude. Certain admonitions and variations are presented Rarely should blunt dissection be attempted in any operation for portal hypertension The relatively avascular organ attachments found in other disease states are not present in portal hypertension. Extensive collateralization is regularly found in the splenocolic ligament (D) the gastrosplenic ligament (E) and the lienorenal ligament (G) Furthermore, highly vascular adhesions usually envelop the spleen and fix it to the diaphragm and the lateral parietal peritoneum. These should be serially clamped, severed, and ligated Blunt dissection is extremely hazardous and may be accompanied by severe blood loss (G)

D through J represent the exposure of the true pedicle from its lateral and posterior aspects. An alternate method is to expose the pedicle from its anterior surface, medial to the splenic hilum. The steps depicted in D through H are followed as shown. At this juncture, several moist laparotomy pads are inserted into the splenic bed" in the subphrenic space, and the spleen is displaced downward and forward The arterial ligation is completed as shown in H However the mobilization of the splenic vein proceeds from the anterior surface of the pedicle as in H rather than rotating the spleen and continuing the dissection as demonstrated in I J and K.

Upon completion of the exposure of the pedicle of the left kidney I find it desirable to identify early the ureter and to "tab" it with cotton tape, similar to the manner in which the renal vein is "tabbed" in M *Occasionally limitations of exposure* make the use of short, spring "bulldog" clamps preferable to the long handle Potts ductus clamps shown in K Individual preference may again call for a modification in technic. The Glover auricular clamp or Satinsky clamp is in my opinion a more versatile instrument than the Potts-Smith clamp used in N A greater surface area of the renal vein may be occluded, which permits the surgeon a wider clearance between the edge of the new stoma and the margin of the occlusive clamp The cutting of an oval opening in the side wall of the renal vein rather than making a linear incised wound as indicated (N) is again an alternative step This facilitates the suture anastomoses and minimizes late stenosis or closure of the stoma site.

In O through S, several modifications are permissible. Instead of using interrupted sutures in the anterior layer (Q) a continuous suture may be used, like that shown for the posterior layer (O) In children interrupted sutures are probably preferable for both the posterior and the anterior layers, to compensate for the increase in the size of the vessels during growth and accordingly to prevent decrease in size of the stoma. Instead of the everting" type of sutures depicted (O Q) a continuous noneverting suture, interrupted only at the angles of the anastomosis, may be used both anteriorly and posteriorly Furthermore, if desired additional "stay sutures may be inserted at each angle prior to the insertion of the continuous sutures forming the anterior and posterior layers of the anastomosis.

DISCUSSION—DRS BLAKEMORE AND VOORHEES (cont.)

Step 2 (Figs. 4 and 5). The noncrushing rubber shod clamp compressing the stump of the splenic vein is released for an instant to allow a rush of venous blood through the splenic vein stump to carry away any clot which may have formed in the splenic vein during the course of the splenectomy Following this, the rubbershod clamp is reapplied, and 20 ml. of a dilute heparin-saline solution are injected into the splenic vein stump proximal to the point of compression by the clamp. The vein is retracted forward, and a usually incomplete collar of pancreatic tissue is divided between clamps along the posterior aspect of the splenic vein stump. Following the division of this areolar and pancreatic tissue for a distance of approximately 3 cm parallel to the posterior aspect of the splenic vein stump, the tail of the pancreas is drawn forward, and the splenic vein is drawn laterally The splenic vein is gradually dissected free from the overlying tail of the pancreas. During this last maneuver it is exceedingly important to identify and to transfix with 00000 braided arterial silk the numerous, tenuous, venous tributaries entering the splenic vein from the tail of the pancreas. If these veins are placed under too much traction, they will tear at their juncture with the splenic vein, and the subsequent repair of the tear in the splenic vein will compromise the lumen and subsequently jeopardize the efficiency of the shunt. The mobilization of the splenic vein stump is carried medially to the point where the inferior mesenteric vein joins the splenic vein.

Step 3 (Fig. 6). The peritoneum overlying the left kidney is incised over the hilus of the kidney This initial line of incision is bisected by a similar peritoneal incision running parallel to the left renal vein. The renal vein is gradually mobilized over a distance of approximately 3 cm. midway between the hilus of the kidney and the vena cava. Two major venous

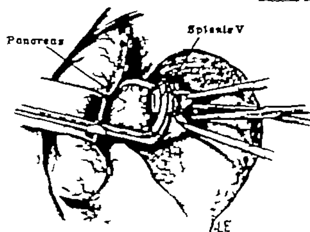


Fig 4 Illustrates beginning mobilization of splenic vein

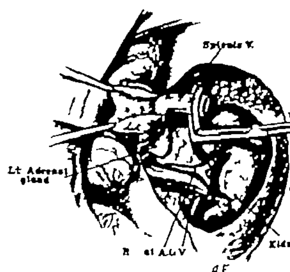


Fig 5 Displays the mobilized stump of the splenic vein Note the tunnel between the left adrenal gland and the upper pole of the left kidney the result of removing retroperitoneal fat.

Discussion—Dr. Welch (cont.)

splenic vein is done posteriorly after mobilization of the spleen and rotating it medially. I do not believe that this technic can be carried out satisfactorily. Mobilization of the splenic vein is best done anteriorly with the spleen in nearly its usual position. The splenic vein is actually partially imbedded in the pancreas. Securing all of the small intrapancreatic tributaries is the important feature of this step.

L, M, N, O, P, Q, R, and S deal with mobilization of the kidney and the actual anastomosis of the end of the splenic vein to the side of the renal vein partially occluded in a Potts-Smith clamp. This would seem to be a good technique employing the everting suture anastomosis. If the renal vein is large, an oval opening can be made in the occluded segment. This is said to make the anastomosis less "slitlike" and less likely to close. A transverse opening in the renal vein may also be made. It tends to gape and stay open, which lessens the likelihood of anastomotic thrombosis. Such an incision requires that the blood supply to the kidney be occluded during the anastomosis. This is done by putting a bull dog clamp on the renal artery to occlude temporarily its blood supply. The actual time needed to complete a splenorenal anastomosis is approximately 20 minutes, which is readily tolerated by the kidney. I have used temporary renal artery occlusion during splenorenal anastomosis in many patients without permanent damage to the kidney as judged by postoperative intravenous pyelograms. This technique is particularly useful when the application of a clamp to partially occlude the renal vein is difficult and awkward.

Discussion—Dr. Louis M. Rousselot. Portasystemic shunts are primarily indicated for the relief of gastroesophageal hemorrhage, by lowering the portal tension in the syndrome of portal hypertension. Dr. Madden's preference is a direct end-to-side portocaval shunt rather than a splenorenal shunt. It is my opinion that a splenorenal shunt be reserved for those cases in which the former is not feasible—i.e., an extrahepatic portal vein block, either congenital or acquired.

The incisions illustrated in A represent standard approaches. The combined thoracoabdominal incision (broken line) gives the optimal exposure. With the combined approach, the abdominal component should be initially opened to confirm the diagnosis and establish operability. An unsuspected hepatoma or a secondary malignant disease that obstructs the portal bed may be established, a biopsy taken, and the operation terminated forthwith.

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The operative steps in A through S are clearly illustrated with exactitude. Certain admonitions and variations are presented. Rarely should blunt dissection be attempted in any operation for portal hypertension. The relatively avascular organ attachments found in other disease states are not present in portal hypertension. Extensive collateralization is regularly found in the splenocolic ligament (D), the gastrosplenic ligament (E), and the lienorenal ligament (G). Furthermore, highly vascular adhesions usually envelop the spleen and fix it to the diaphragm and the lateral parietal peritoneum. These should be serially clamped, severed, and ligated. Blunt dissection is extremely hazardous and may be accompanied by severe blood loss (G).

D through J represent the exposure of the true pedicle from its lateral and posterior aspects. An alternate method is to expose the pedicle from its anterior surface, medial to the splenic hilum. The steps depicted in D through H are followed as shown. At this juncture, several moist laparotomy pads are inserted into the splenic "bed" in the subphrenic space, and the spleen is displaced downward and forward. The arterial ligation is completed as shown in H. However, the mobilization of the splenic vein proceeds from the anterior surface of the pedicle as in H, rather than rotating the spleen and continuing the dissection as demonstrated in I, J, and K.

Upon completion of the exposure of the pedicle of the left kidney, I find it desirable to identify early the ureter and to "tab" it with cotton tape, similar to the manner in which the renal vein is "tabbed" in M. Occasionally limitations of exposure make the use of short, spring "bulldog" clamps preferable to the long handle Potts ductus clamps shown in K. Individual preference may again call for a modification in technic. The Glover auricular clamp or Satinsky clamp is in my opinion a more versatile instrument than the Potts-Smith clamp used in N. A greater surface area of the renal vein may be occluded, which permits the surgeon a wider clearance between the edge of the new stoma and the margin of the occlusive clamp. The cutting of an oval opening in the side wall of the renal vein rather than making a linear incised wound as indicated (N) is again an alternative step. This facilitates the suture anastomoses and minimizes late stenosis or closure of the stoma site.

In O through S, several modifications are permissible. Instead of using interrupted sutures in the anterior layer (Q) a continuous suture may be used, like that shown for the posterior layer (O). In children interrupted sutures are probably preferable for both the posterior and the anterior layers, to compensate for the increase in the size of the vessels during growth and, accordingly, to prevent decrease in size of the stoma. Instead of the "everting" type of sutures depicted (O, Q), a continuous noneverting suture, interrupted only at the angles of the anastomosis, may be used both anteriorly and posteriorly. Furthermore, if desired, additional "stay" sutures may be inserted at each angle prior to the insertion of the continuous sutures forming the anterior and posterior layers of the anastomosis.

DISCUSSION—DR. C STUART WELCH The indications for the use of an anastomosis from splenic vein to renal vein instead of a direct portacaval shunt have diminished greatly in the past ten years. In our hospital today we seldom perform splenectomy and splenorenal shunt. Splenorenal shunt had its vogue because technically it seemed to be a less dangerous procedure than portacaval shunt. That is to say it avoided dissection in the hepatic pedicle, where injury to the common bile duct, hepatic artery and indeed the portal vein itself might occur With increasing experience with the right-sided operation (portal vein to vena cava shunt) it became apparent that splenorenal anastomosis was more difficult and time-consuming than was a portacaval anastomosis. But, most important, the rate of recurrent bleeding from esophageal varices directly caused by thrombosis or closure of the splenorenal shunt was found to be high—much higher than in portacaval shunts when late results were evaluated (30 per cent for the former as contrasted to 2 per cent or less for the latter)

The reason for the high rate of splenorenal shunt failures is technical The splenic vein is smaller than the portal vein. Furthermore, angulation and slowing of the current of shunted blood can occur encouraging clotting. Splenorenal anastomosis is a rather awkward shunt.

As an indication for the use of splenectomy and splenorenal shunt, most surgeons accept the absence of a useful portal vein, as is found in extra hepatic portal hypertension due to congenital or acquired obliteration of the portal vein as a prime indication. The one difficulty with using splenorenal anastomosis in such cases is that variceal bleeding occurs in very young patients with extra hepatic bed block. In these patients the splenic vein is often so small as to invite anastomosis failure if it is used Experience has shown that splenorenal anastomosis is doomed to failure in the very young. It is only when the child passes 10 years of age that a good sized splenic vein can be a reasonable hope Even then the site for splenic vein anastomosis must be as near the portal vein as possible to secure a good lumen. Bleeding from varices in the very young can be temporarily controlled by such expediencies as small esophagogastric resection and jejunal or colonic interposition. This operation has more success than simple ligation of esophageal varices. By employing methods for the temporary control of bleeding, the child grows in the meantime and there is hope that a large splenic vein will be found and a satisfactory splenic renal vein decompression can be fashioned

The remark made above about the indications for splenorenal shunt must be taken with some reservation now that another alternative shunt has been found to be useful in the very young This is the Marion Shunt which is performed by anastomosis of the cephalad cut end of the vena cava below the renal veins to the side of the superior mesenteric vein The technic of this shunt is not part of the present discussion. Suffice it to say that its employment as thus far reported indicates that a more substantial shunt can be performed by the Marion technic than by the splenorenal method and that, therefore the indications for splenorenal shunts are again lessened.

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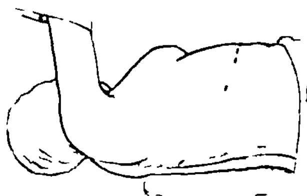
In regard to the technic of splenectomy and splenorenal anastomosis depicted in the illustrations, there is some area for disagreement although the variation which I will point out may be personal

At any rate, in reference to A, B, and C, I offer the following comments. I believe that the thoracoabdominal incision is the best choice for this procedure, and I normally use it. I hold the opposite view for portacaval shunt (abdominal exposure only) Exposure is much more adequate with a left thoracoabdominal incision than a subcostal incision, both for the performance of the dissection and the shunt. There may be very troublesome bleeding to control during the operation of splenectomy and splenorenal shunt in the following instances Vascular adhesions of the spleen to the diaphragm are often troublesome. Large and multiple retroperitoneal collaterals from the spleen, particularly laterally may be difficult to manage without a large exposure. Pancreatic tributaries of the splenic vein must be carefully dissected and ligated to prevent abnormal blood loss. Finally dissection in and about the kidney pedicle is facilitated by the thoracoabdominal exposure. Therefore, I always make a thoracoabdominal incision when I perform a splenorenal shunt.

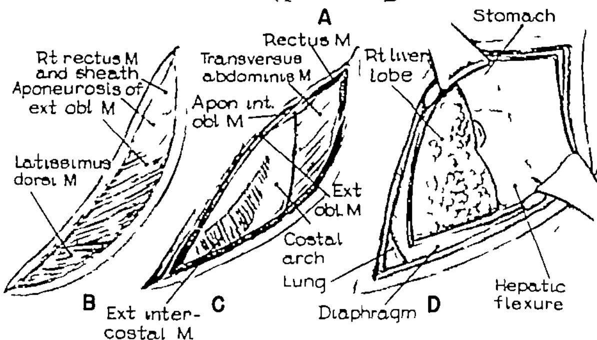
In reference to D E, and F I would like to comment on the matter of preliminary ligation of the splenic artery It is true that splenic artery ligation helps control bleeding from the spleen and its collaterals during its mobilization and removal but I believe that it is not a necessary preliminary step I prefer to perform step G (lateral mobilization of the spleen) first and do not ligate the splenic artery unless bleeding is excessive My reason for doing so is that a large full splenic vein is more easily dissected

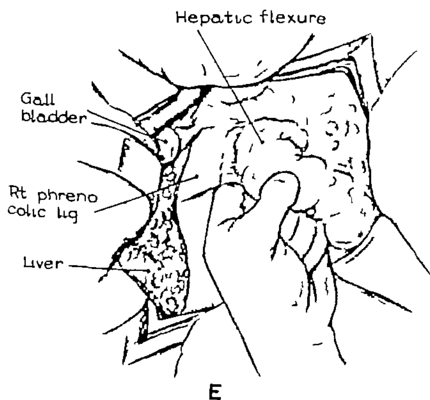
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I, J and K, would indicate that dissection of the


A


A′


Rt rectus M and sheath
Aponeurosis of ext obl M
Latissimus dorsi M
B
Rectus M
Transversus abdominis M
Apon int. obl M
Ext obl M
Costal arch
Ext inter-costal M
C
Stomach
Rt liver lobe
Lung
Diaphragm
Hepatic flexure
D


Hepatic flexure
Gall bladder
Rt phreno colic lig
Liver
E

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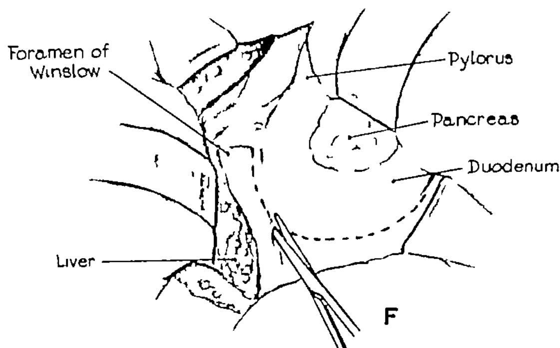
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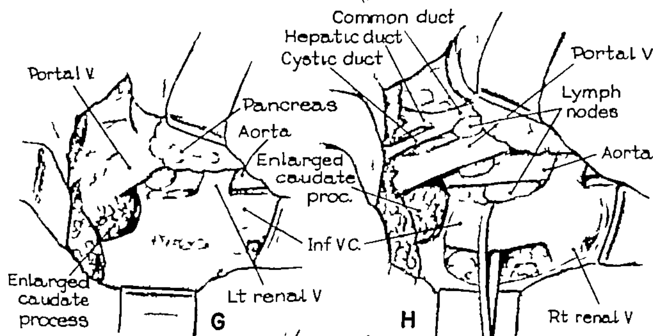
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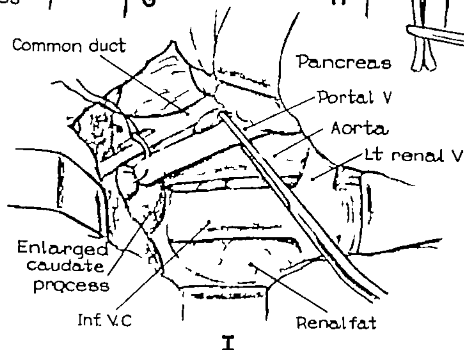
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Foramen of Winslow
Pylorus
Pancreas
Duodenum
Liver
F


Common duct
Hepatic duct
Cystic duct
Portal V
Portal V
Pancreas
Lymph nodes
Aorta
Aorta
Enlarged caudate proc.
Inf V.C.
Enlarged caudate process
Lt renal V
Rt renal V
G
H


Common duct
Pancreas
Portal V
Aorta
Lt renal V
Enlarged caudate process
Inf V.C
Renal fat
I

F The mobilized hepatic flexure of the colon is displaced downward toward the left lower quadrant of the peritoneal cavity and the foramen of Winslow, the pylorus, the head of the pancreas, and the retrocolic portion of the duodenum are exposed Mobilization of the descending portion of the duodenum is commenced by scissor dissection of the posterior parietal peritoneal layer along its lateral border (Kocher maneuver). Normally this peritoneal layer like the posterior layer of the lienorenal ligament, is avascular and may be severed with impunity However in the presence of portal hypertension, the application of clamps to prevent excessive blood loss may be required.

The mobilization of the duodenum as depicted is no longer practiced This maneuver was often associated with unnecessary blood loss and prolongation of the operation Instead, dissection of the portal vein is immediately commenced and is then followed by mobilization of the inferior vena cava.

G The mobilized segment of the duodenum and the head of the pancreas are retracted toward the midline to expose the related structures as depicted

H. The dissection is continued, and the structures are now more clearly visualized. The dissection and isolation of the structures shown is both tedious and difficult because of the edema and increased vascularity of the tissues. The mobilized segment of the inferior vena cava is encircled by a traction tape of rubber tissue and partially retracted to expose clearly the group of lymph nodes between the aorta and the inferior vena cava.

I. The portal vein is occluded, first proximally with an angulated Potts ductus clamp and then distally with a ligature and a suture ligature of silk (00) respectively The site for transection of the portal vein is indicated in dotted outline The convergence cephalad of the portal vein and the inferior vena cava and their separation by the caudate process of the liver may be readily seen. In some instances, partial resection of an enlarged caudate process, as suggested by Blakemore, may be required to permit the performance of a portacaval shunt

Discussion—Drs Blakemore and Voorhees (cont.) the bed of the ninth rib, incising the diaphragmatic pleura and peritoneum, and splitting the diaphragm in the course of its muscle fibers for approximately 12 to 15 cm. After general abdominal examination and confirmation of the diagnosis, a specimen for biopsy is obtained from the right lobe of the liver by making a cruciate incision through the liver capsule on the anterior margin and inserting a cork borer of approximately 5 mm. in diameter to the depth of 4 cm. The plug of liver tissue thus obtained is immediately given to the pathologist for early fixation. Bleeding from the biopsy site is controlled by suitably placed mattress sutures tied over a plug of skeletal muscle.

For the sake of convenience, the subsequent operative procedure can be divided into three parts. The first step is that of mobilization of the duodenum and

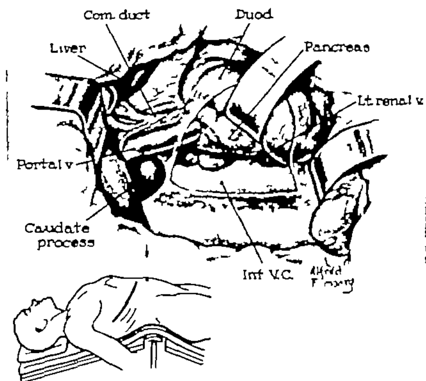
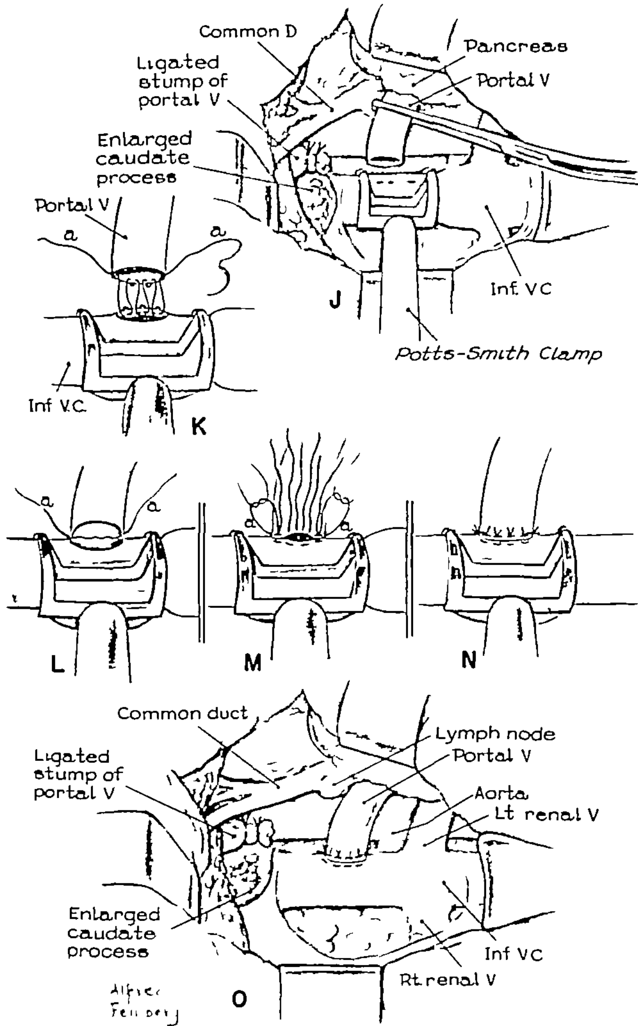


Fig 1


Common D
Pancreas
Ligated stump of portal V
Portal V
Enlarged caudate process
Portal V
a
a
J
Inf. VC
Potts-Smith Clamp
Inf V.C.
K
a
a
a
a
L
M
N
Common duct
Lymph node
Ligated stump of portal V
Portal V
Aorta
Lt renal V
Enlarged caudate process
Inf VC
Rt. renal V
O

J. The whole of the circumference of the inferior vena cava superior to the renal veins is completely mobilized, and its lumen is partially occluded by a Potts–Smith clamp. However, if desired, a Potts curved portacaval clamp may be used. The advantage of this type of clamp is that a longitudinal segment of the inferior vena cava may be occluded without the necessity of mobilizing the whole of the circumference of the inferior vena cava. The proximal transected end of the portal vein is turned downward toward the inferior vena cava preliminary to the performance of the venovenous shunt. The dotted line in the occluded segment of the inferior vena cava indicates the site of the incision for the anastomosis.

This type of clamp or one of the Beck-Potts type is now preferred.

K. The posterior suture layer of the anastomosis is inserted. This is a continuous eversion type of suture (silk, 00000) with intima to intima approximation. The suture is commenced from the "outside in" on the portal vein and terminates from the "inside out" also on the portal vein. Between its commencement and termination, the suture proceeds from the "inside out" to the "outside in" relative to the lumens of the portal vein and the inferior vena cava. Accordingly, the loops formed by the suture are always on the outside of the lumen of the vessel.

L. The posterior suture, a–a, is drawn taut, and the intimal surfaces of the portal vein and the vena cava are in close approximation. None of the silk suture is exposed within the lumen.

M. A series of interrupted everting mattress sutures of silk (00000) is employed for the anterior layer of the anastomosis. All of these sutures are first inserted and then tied. The mattress sutures at either end are tied first, and one of the long ends of each of these sutures is in turn tied to either end a–a of the continuous everting suture of silk used for the posterior layer.

N. The intervening mattress sutures are tied to complete the anterior layer of the anastomosis.

A single continuous over-and-over suture is now used routinely instead of the everting sutures as illustrated. However, the mattress stay sutures at each angle are still employed. The needle strand of each mattress suture is continued as an over-and-over suture to terminate in the center of the anastomosis anteriorly.

O. The operative field upon completion of the end-to-side portacaval shunt is shown.

DISCUSSION—DRS. BLAKEMORE AND VOORHEES (cont.) identification and partial mobilization of the inferior vena cava. The second step is identification and mobilization of the portal vein. The third step is the anastomosis of the portal vein to the vena cava.

Step 1 (Fig. 1). The peritoneal reflection overlying the first and the second portions of the duodenum is incised along the greater curvature of the first and second portions of the duodenum. By blunt and sharp dissection, the first and second portions of the duodenum are rolled toward the midline. When the under surface of the pancreas can be identified along the lesser curvature of the duodenum, the medial mobilization of the duodenum has been sufficient. With the duodenum in its medial reflected position, the vena cava lies immediately posterior to the area from *which the second portion of the duodenum was re*flected. The overlying strands of areolar tissue can be divided with safety along the anterior midline of the vena cava. If the right spermatic or ovarian vein is visible, the anterior mobilization of the vena cava has been begun too far caudad. For the purposes of the operation, it is usually sufficient to mobilize only the anterior and medial aspects of the vena cava from the level of the left renal vein to the caudate isthmus of the liver. Mobilizing the right lateral aspect of the vena cava in this region is unnecessary and extremely hazardous because of the numerous veins coming from the adrenal gland and entering the vena cava directly. It is also important to identify with precision the left renal vein since it will subsequently represent a landmark in selection of the site of anastomosis. In certain patients, hypertrophy of the caudate process may encroach upon the subsequent site of anastomosis, and, in these instances, the caudate process must be resected (Fig. 2). When this is the case, it is necessary to ligate two or more pairs of minute veins running from the caudate process to the vena cava. These are frequently unrecognized during manipulation of the process and may be torn, giving rise to troublesome hemorrhage in an area difficult to control. Once the caudate process has been freed from the underlying vena cava, it can be cross-clamped and resected. Hemostasis is achieved by multiple vertical mattress sutures placed approximately 1 cm. from the cut margins.

Step 2. It must be remembered that, with the patient in a hyperextended left semilateral position, the operator is usually looking at the right lateral aspect of the hepatoduodenal ligament, and, in this position, the common duct lies in an anterior location and the portal vein in a posterior location in the ligament (Fig. 1). The peritoneal investment of the hepatoduodenal ligament is incised in the posterior right lateral aspect of the hepatoduodenal ligament from the porta hepatis to the greater curvature of the duodenum. In making this incision, care should be exercised to avoid cutting unnecessarily any recognizable lymphatic channels. Once the peritoneum is incised, the vein can usually be identified by finger dissection and palpation. Upon identification, the

vein should be dissected bluntly in the adventitial plane at roughly its midportion between the porta hepatis and the head of the pancreas. Following local circumferential dissection of the vein, a short piece of umbilical tape can be passed about the vein for the purpose of gentle traction. This serves as a useful method for avoiding unnecessary instrumentation of a vein subsequently to be used as a shunt. The dissection is carried cephalad to the porta hepatis. The bifurcation of the portal vein into the right and left hepatic veins should be identified. This represents the highest point of dissection, and at this time there are usually no significant venous tributaries which must be dealt with. The portal vein is mobilized caudad by sharp and blunt dissection to the level of the head of the pancreas. Two major tributaries to the portal vein, if unrecognized, may tear and cause troublesome hemorrhage. The first tributary is on the medial aspect of the portal vein and enters directly into the head of the pancreas. The second tributary is on the lateral inferior aspect of the portal vein, just beneath a collar of pancreatic tissue where the portal vein emerges from the head of the pancreas. Both tributaries should be identified and individually ligated by transfixion ligatures of 00000 braided silk. After mobilization of the portal vein, it is appropriate to make initial pressure readings in the portal system from a large branch of the gastroepiploic vein. Simple manometric readings, using the manubrial notch as the reference point, should be made with the portal vein open and then with the portal vein compressed. If the pressure rise following compression of the portal vein is in excess of 150 mm. of saline, then a side-to-side portal vein to-vena cava anastomosis is advised. As the last portion of this second step in preparation for an end-to-side anastomosis, a ligature of heavy silk is passed about the portal vein at the level of the bifurcation into the right and left hepatic veins. The ligature is tied, and a second transfixion suture employing 00 braided silk is placed approximately 3 mm. from the primary tie. A rubbershod clamp that will occlude, but not crush, the vein is placed around the vein as it emerges from the head of the pancreas, and the vein is transected immediately proximal to the transfixion suture. Twenty to thirty milliliters of a solution of heparin containing 10 mg. of heparin in 100 ml. of saline is instilled in the portal vein proximal to the rubbershod clamp. 2-3 mg

Step 3. An imaginary line coursing parallel to the vena cava on its anterior medial aspect, equidistant from the true anterior aspect of the vena cava and the true left lateral aspect of the vena cava, which may be indentified by the juncture of the left renal vein, is defined and marked by two arterial silk sutures as the future axis of the anastomosis (Fig. 3). The vena cava is tended and grasped by a Beck-Potts clamp. An oval "window" is then cut in the vena cava, corresponding in diameter to the fully distended portal vein. The anastomosis is placed as near to the liver as practical so that the angle formed between the portal vein and the vena cava will be an acute angle 45 to 60 degrees. A single layer anastomosis is achieved by a simple over and over suture of 00000 braided silk. It is desirable to exert some tension on the angle stay sutures during the anastomosis to avoid pursestringing the stoma. In the posterior suture line, care must be exercised to avoid dragging small strands of adventitial tissue into the suture line by the suture material. After completion of the anastomosis, the vena cava clamp is released first, and the portal vein clamp released second. Anastomoses in a low pressure system rarely leak seriously and minimal suture line leaks occurring shortly after the removal of the clamps should be controlled by simple finger pressure over the area. Unless the suture line leak is a serious one, reinforcing sutures should not be taken since they may cause distortion or constriction of the stoma. Once flow has been established in the newly formed shunt, the point of emergence of the portal vein from the region of the head of the pancreas should be carefully examined. Frequently a collar of pancreatic tissue will cause angulation or actual compression of the portal vein in its newly established course. If this collar exists, a wedge of pancreatic tissue should be excised (Fig. 4). This compression feature is an exceedingly important one

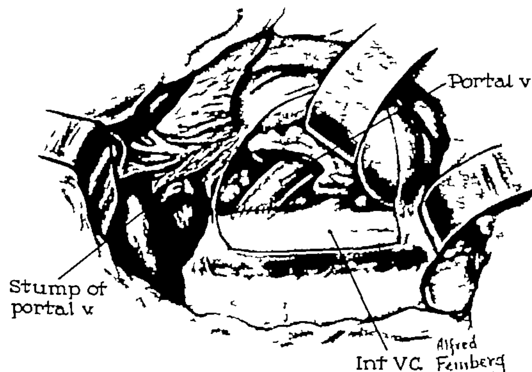


Fig. 4

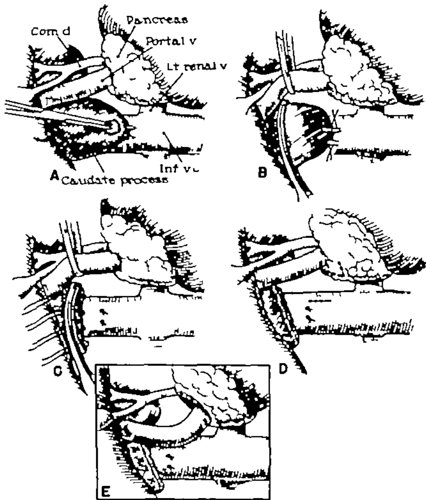

Pancreas
Com d
Portal v
Lt renal v
Inf vc
A
Caudate process
B
C
D
E

Fig 2

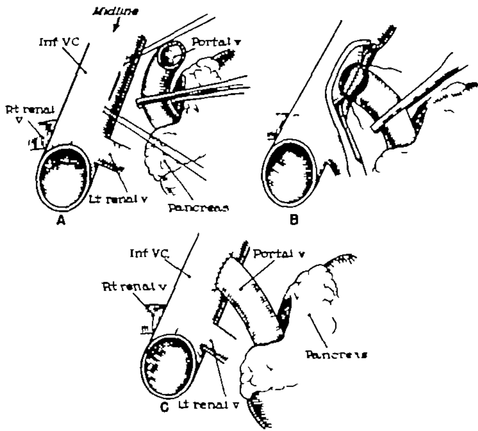

Midline
Inf VC
Portal v
Rt renal v
Lt renal v
Pancreas
A
B
Inf VC
Portal v
Rt renal v
Pancreas
C
Lt renal v

Fig 3

Discussion—Dr. C Stuart Welch The illustrations show a technic for end-to-side portacaval shunt that deals with the incision, a minor part of the dissection, and the anastomosis. I shall deal with each of these items separately

First, the right thoracoabdominal incision shown is unnecessary for 90 or 95 per cent of portacaval shunts. Thoracoabdominal incisions consume time in opening and closing and also result in greater blood loss and thus greater need for replacement Patients with liver cirrhosis should have the least number of blood transfusions possible. It also is a fact that opening the pleural cavity invites pulmonary complications and morbidity I use a subcostal abdominal incision, as depicted in A The right side of the patient is elevated 30 off the table, and the incision is begun halfway between the xiphoid process and the umbilicus. It is then directed to the right under the rib cage extending beneath the twelfth rib in the costovertebral angle One indication for a thoracoabdominal incision is a very large liver

It is, of course, impossible for the author to depict the dissection because of the variability of the disease, but this is the most important and difficult part of the operation I first expose the inferior vena cava, because this maneuver is quite easy and establishes an important landmark.

Next I dissect the portal vein. The important point in this dissection is to know where this vein is. It is posterior and medial in the hepatic pedicle. In most cases there is no need to make a formal Kocher mobilization of the duodenum There is also no need to first expose the common duct or hepatic artery The portal vein can be approached directly by putting the right hand to the left of the hepatic pedicle and exerting pressure posteriorly and to the right at the same time that the left hand dissects out the portal vein The most annoying part of the dissection is encountered in dealing with the large vascular lymph glands that surround the portal vein and lie between it and the vena cava All of the tributaries of the portal vein are medial, and they vary in number from none to three or four They must be accurately secured. Once the vein is free it remains only to decide whether or not a nick should be made in the pancreas to allow a freer right angle swing of the portal vein to meet the vena cava. The next step is a high severance of the portal vein at its bifurcation Here I recommend a free tie of 00 silk, distal to which I place a suture ligature.

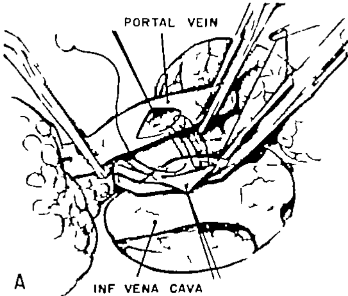
Relative to the anastomosis, there is little of importance to say An ellipse should be cut out of the vena cava I prefer an everting type of suture anastomosis. The clamp shown in the drawings is an awkward one and would seem to require unneeded mobilization of the cava. A Satinsky clamp or Thomas Smith intestinal clamp is much easier to use. Mobilization of the cava posteriorly and medially is unnecessary and may result in bleeding from lumbar tributaries. The posterior row of sutures need not be laid and then drawn the suture line can be made with continuous approximation. Most surgeons believe that an everting anastomosis is unnecessary and if they are correct, the anastomosis is that much easier At any rate, the anastomosis is the least difficult part of the operation

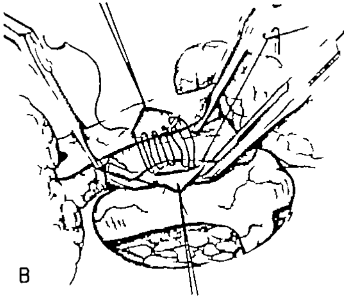
DISCUSSION—DRS. BLAKEMORE AND VOORHEES (cont.)

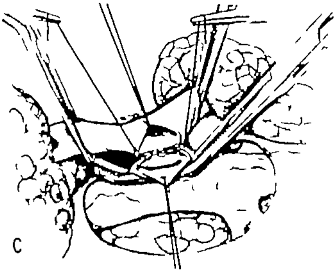
and may not be recognized by a cursory examination It must be actively looked for

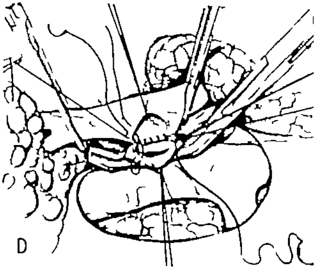
In those instances where side to-side anastomoses between the portal vein and the vena cava are deemed advisable because of a pressure rise in the portal system in excess of 150 mm. of saline following compression of the portal vein, the portal vein is not divided Contiguous surfaces of the vena cava and portal vein are marked by arterial sutures, the vena cava is grasped by a Beck-Potts clamp in a fashion similar to that previously described, and a 15 mm. diameter oval "window" is cut (Fig 2). The portal vein is temporarily occluded above and below the site of anastomosis by a simple double turn of umbilical tape, and a corresponding 15 mm. diameter oval "window" is cut in the previously marked site. The anastomosis is accomplished in precisely the same manner as that described for the end to-side anastomosis.

After completion of the portal vein-to-vena cava shunt, manometric pressures are again recorded in the portal system, with and without portal vein compression. In ideal circumstances, the pressure in the portal system should be less than 200 mm. of water pressure. If this pressure has not been achieved, the possibility of mechanical impediment to flow by distortion of the portal vein, or at the site of anastomosis, should be excluded by inspection. In the closure of the operative wound, no attempt is made at reperitonization or closing the retroperitoneal tissues over the site of anastomosis. The abdominal and thoracic portions of the wound are anatomically reconstituted. The abdomen is closed without drainage, and the chest cavity is closed over a large caliber catheter which is withdrawn at the conclusion of the chest closure after residual air and fluid have been evacuated from the cavity


PORTAL VEIN
A
INF VENA CAVA


B


C


D

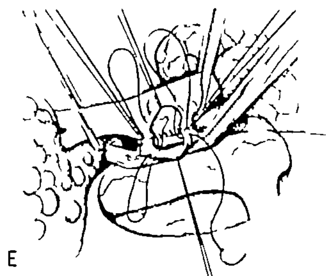
SIDE TO SIDE PORTACAVAL SHUNT

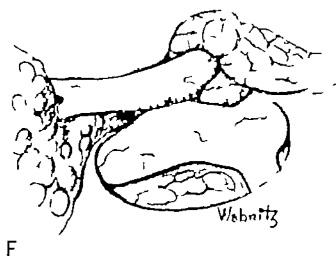
A, B. The portal vein is cross-clamped caudad and cephalad by angulated Potts clamps Next, a tented segment of the inferior vena cava, cephalad to the renal vein tributaries, is occluded in a Beck Potts clamp Openings (2.5-3 cm.) are then made into the lumen of the portal vein and the lumen of the occluded segment of the inferior vena cava preparatory to their anastomosis A continuous suture of 00000 silk swedged on a small curved needle is used for the posterior layer This suture is started from the outside in at the caudad angle of the opening in the inferior vena cava (A) It is then continued as a simple over and-over suture to terminate from the inside-out at the cephalad angle of the opening in the portal vein (B) To facilitate its insertion, guy sutures (00000 silk) for traction are inserted in the anterior margins of the openings in the inferior vena cava and portal vein (A, B)

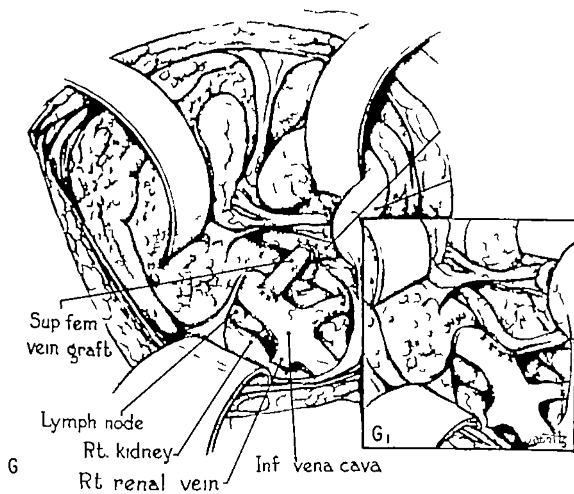
The use of a continuous over and-over suture though theoretically objectionable because of the silk strands within the lumen, has proved most satisfactory in practice and is preferred to the continuous everting mattress suture

C. The posterior suture is drawn taut, and the respective cut margins of the portal vein and vena cava are firmly approximated.

D Interrupted everting mattress sutures are inserted at either angle of the anastomosis. The mattress suture at the caudad angle is tied, and its needle free strand is being tied to the caudad end of the posterior suture The insertion of the mattress suture at the cephalad angle is completed, and its needle free strand will be tied to the cephalad end of the posterior suture


E


Wabnitz
F


Sup fem vein graft
Lymph node
Rt. kidney
Rt renal vein
Inf vena cava
G₁
G

E, F The needle strands of the everting mattress sutures at either angle are continued as simple over-and-over sutures (E) to terminate in the center of the anastomosis anteriorly where they are tied to each other and the strands cut to complete the anastomosis (F) Just prior to completion of the anastomosis, the traction guy sutures, visible in E, are withdrawn

G, G_1 A completed direct side-to-side shunt, using interrupted everting mattress sutures, is shown (G_1) In some instances when a direct side-to-side shunt is not feasible technically it may be effected by the interposition of an autogenous vein (superficial femoral) graft, the so called H graft (G)

DISCUSSION—DR. C. STUART WELCH. Anastomosis of the portal vein to the vena cava done by a tangential technic is the original Eck fistula and can be done instead of end-to-side portacaval shunt for the prevention of bleeding from esophageal varices. It also has, I believe, a preferential place in the surgical treatment of certain cases of ascites. Some discussion of the indications for this shunt is apropos, because there are some surgeons who never use it and admit of no indication for its use.

If the problem before the surgeon is simply to reduce splanchnic portal pressure in a patient who has survived a hemorrhage from esophageal varices, a simple end-to-side shunt with interruption of the portal vein suffices. I say this because there is no question that end-to-side anastomosis is much more easily performed. However a side-to-side shunt, if well made, is equally good functionally and is not harmful provided the anastomosis is not too large. If too large it predisposes to ammonia intoxication. A shunt of 2 or 2.5 cm. is of sufficient size and need not be exceeded.

The special indication for a side-to-side portacaval shunt is persistent and intractable ascites. The rationale of the use of this type of shunt in the treatment of ascites is based on the supposition that decompression of the liver may be obtained by retrograde portal blood flow. Time does not permit a complete discussion of the cause of ascites. Suffice it to say there is evidence of outflow block in the liver and evidence that reverse or retrograde portal blood flow in a side-to-side portacaval shunt *can* prove beneficial. From the practical standpoint, the use of this type of shunt has cured patients with ascites. Although it should not be applied to all patients with ascites, it is difficult to lay down rules for its application. However in the surgical management of patients with ascites, a side-to-side shunt is believed superior to an end-to-side shunt.

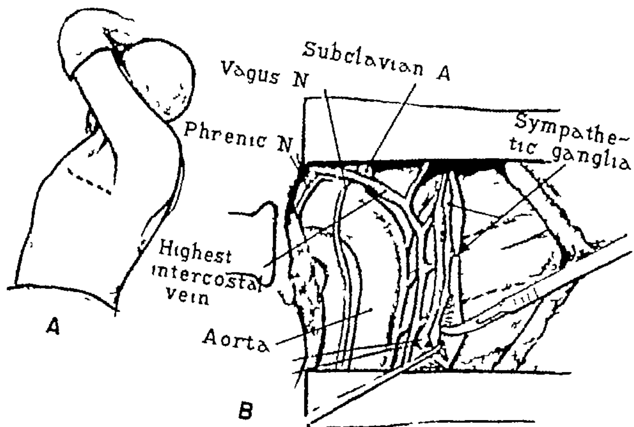
From the technical standpoint, several features bear comment. Nothing is said about the incision in the illustrations. The right side of the patient should be elevated about 30° from the horizontal and a large subcostal abdominal incision employed. A thoracoabdominal incision should not be used routinely. It is time-consuming and the morbidity is high. It is only when one is dealing with a very large liver that a planned thoracoabdominal incision is needed. The subcostal incision begins at the linea alba halfway between the xiphoid process and the umbilicus and extends under the twelfth rib to the costovertebral angle.

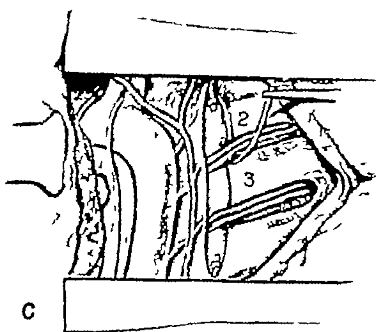
A side-to-side shunt is not technically feasible in all patients because of the distance between these two veins and the interposition of the caudate lobe. I would estimate that it can be done in 75 per cent of the patients. Two technical maneuvers are especially helpful in making a good side-to-side shunt (1) resection of the caudate lobe and (2) mobilization of the vena cava. "If the mountain will not go to Mahomet, Mahomet must go to the mountain." To effect this mobilization, the right renal vein must be loosened. If a side-to-side shunt adequate in size and without tension or angulation is not possible it should not be done. An end-to-side is a good alternative. I mention this because a poorly made side-to-side shunt is doomed to failure by thrombosis.

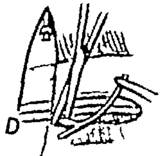
The illustrations depict a side-to-side shunt that is very easy to do, and I would warn that the technical difficulties described previously bear consideration. It is good to take ellipses out of both the portal vein and the vena cava as a preliminary to the anastomosis. I also favor an everting stitch because it leaves so little suture material exposed within the lumen.

In some instances a side-to-side shunt can be done by using a high transverse incision in the inferior vena cava when it would be impossible with a longitudinal incision as shown in the drawings. Then Satinsky clamps are applied at right angles to the cava.

Finally I would never recommend an H shunt using an autogenous femoral vein. In such grafts the incidence of thrombosis is high. It is better to do an end-to-side anastomosis even though a side-to-side would be more desirable if the former seems too difficult. In some instances, ascites has been relieved by an end-to-side portacaval shunt.


Subclavian A
Vagus N
Phrenic N
Sympathetic ganglia
Highest intercostal vein
Aorta
A
B


2
3
C


D

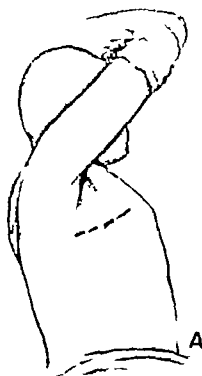
LEFT TRANSAXILLARY TRANSPLEURAL THORACIC SYMPATHETIC GANGLIONECTOMY

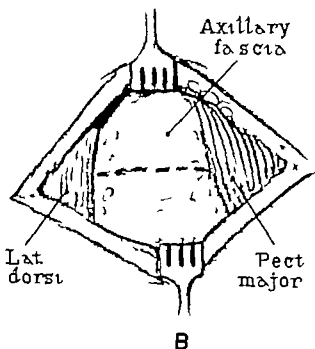
A. The patient is placed in the direct right lateral prone position and the transaxillary incision is indicated (broken line)

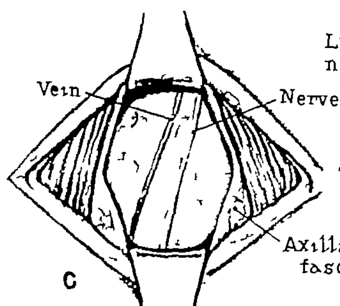
B. The left pleural cavity is entered, and the rib cage retracted to expose the opening in the posterior parietal pleura and the start of the mobilization of the sympathetic chain and ganglia. The neighboring intrathoracic structures are visible The broken lines in relation to the lower borders of the second and third ribs indicate the incisions to be made in the parietal pleura for the exposure of the second and third thoracic nerves.

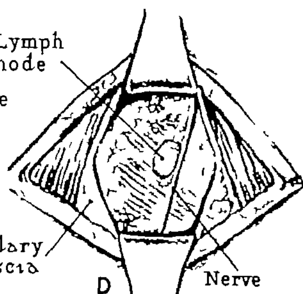
C. The segmental resection of the sympathetic chain and ganglia (D2, D3 and D4) and the third intercostal nerve is completed The second intercostal nerve is transected, and its clamped posterior segment is being mobilized to expose its anterior (motor) and posterior (sensory) roots.

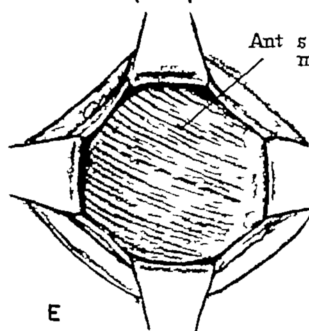
D The anterior root is transected, and the posterior root is being severed with scissors just distal to its sensory ganglion. In this dissection the subarachnoid space may be entered and cause a leakage of spinal fluid. In the experience of the author the inclusion of the segmental resection of the somatic nerves (T2 and T3) has not been associated with an improvement when compared with the clinical results obtained when this is not done.

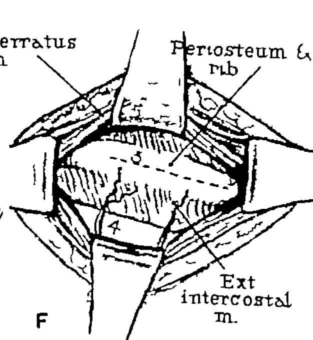

A


Axillary fascia
Lat dorsi
Pect major
B


Vein
Nerve
Axillary fascia
C


Lymph node
Nerve
D


Ant serratus m
E


Periosteum & rib
5
4
Ext intercostal m.
F

RIGHT TRANSAXILLARY TRANSPLEURAL THORACIC SYMPATHETIC GANGLIONECTOMY

A. The patient is placed in the direct left lateral prone position, and the flexed right upper extremity is elevated and supported above the head. The transverse skin incision (broken line) overlies the third intercostal space and extends from the lateral border of the pectoralis major muscle to the anterior border of the latissimus dorsi muscle

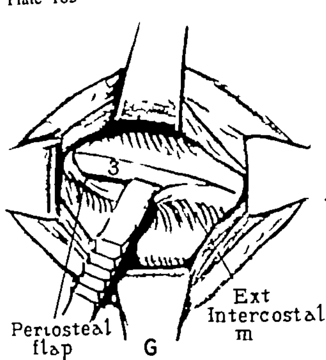
B. The incision is deepened through the subcutaneous fatty tissue layer to expose the line of incision (broken line) in the axillary fascia.

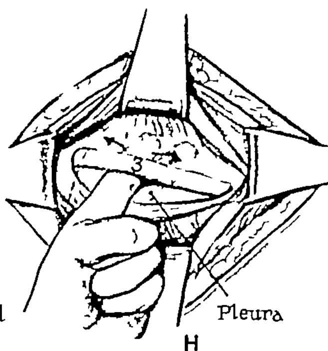
C. The transected tissue layers are retracted, and the lateral cutaneous branch (intercostohumeral) of the second thoracic nerve with an accompanying vein are shown within the surrounding fatty areolar tissue. A lymph node between the nerve and vein is faintly outlined.

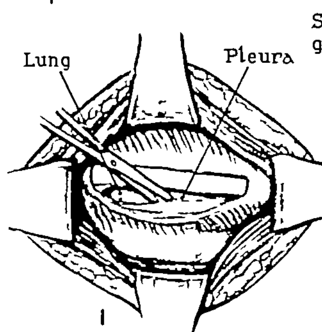
D The fatty areolar tissue is cleared to show clearly the lymph node and the intercostohumeral nerve in relation to the anterior serratus muscle The ligated ends of the severed vein are also visible.

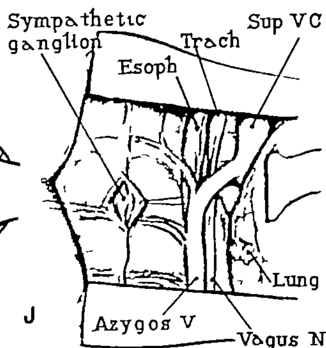
E. The nerve is retracted anteriorly and the incision in the anterior serratus muscle is indicated (broken line)

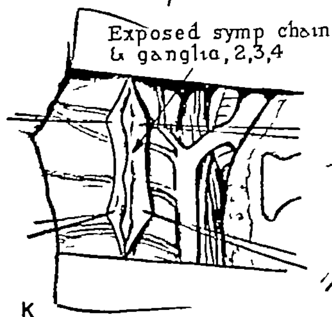
F The cut margins of the muscle are retracted, and the periosteum overlying the third rib is incised (broken line) The blood vessels arching upward from below the fourth rib may be seen.

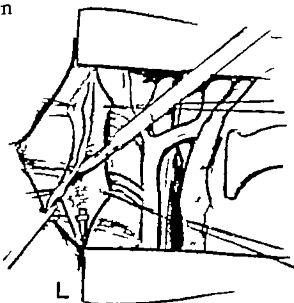

3
Periosteal flap
G
Ext Intercostal m


3
Pleura
H


Lung
Pleura
I


Sympathetic ganglion
Sup VC
Trach
Esoph
Lung
J
Azygos V
Vagus N

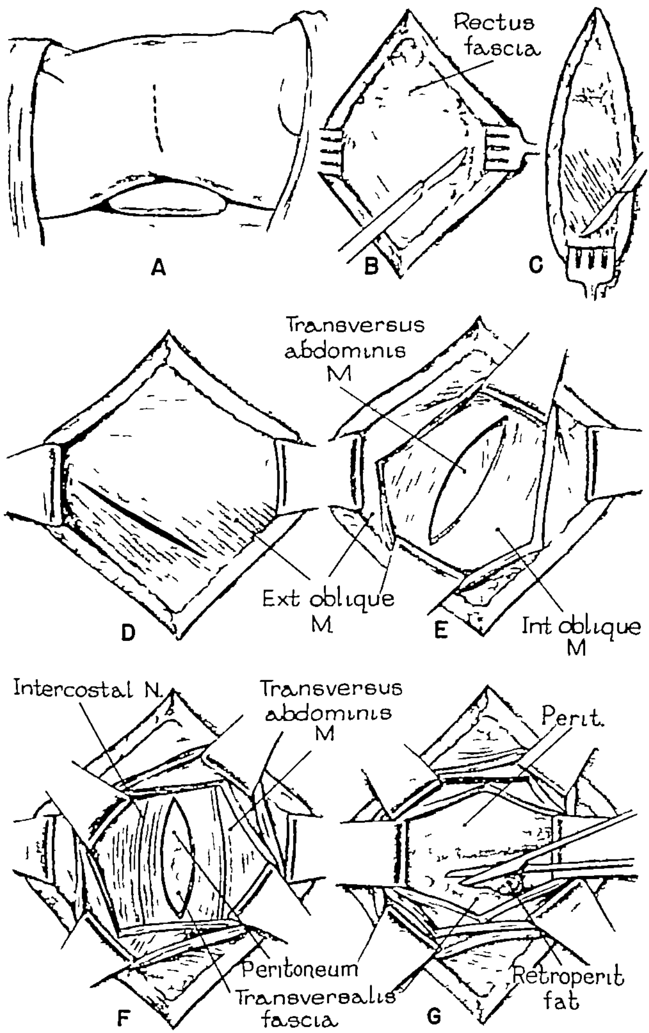

Exposed symp chain & ganglia, 2,3,4
K


L

G, H. The lower half of the periosteum is separated from the third rib (G) and the left index finger is inserted between the separated periosteum and the rib (H) to mobilize it by blunt dissection from the underlying endothoracic fascia and parietal pleura (Brock technic)

I, J K. An opening previously made into the pleural cavity is extended by scissor dissection (I) and the adjacent ribs (third and fourth) are retracted (J) The cut margins of the posterior parietal pleura are retracted with guy sutures of silk (0000) and the thoracic sympathetic chain and ganglia in relation to the adjacent structures are visible (J K)

L. The thoracic sympathetic chain is transected between a silver clip (Cushing) and clamp caudad to the fourth ganglion and is then mobilized cephalad by sharp dissection using a curved knife blade (No 12)


Rectus fascia
A
B
C
Transversus abdominis M
Ext oblique M
D
E
Int oblique M
Intercostal N.
Transversus abdominis M
Perit.
Peritoneum
Transversalis fascia
Retroperit fat
F
G

LEFT LUMBAR SYMPATHETIC GANGLIONECTOMY

A. The patient is placed in the supine position, *and the left side is elevated on a pillow support to approximately a 25 degree angle to the horizontal.*

B. Traction with a multipronged (rake) retractor is maintained upward on the upper flap as its mobilization is completed by scalpel dissection. The lower flap was previously mobilized in like manner

C. The outer angle of the incision is also mobilized by scalpel dissection until the musculature of the lateral abdominal wall is readily visible

D The mobilized skin margins are retracted, and the incision in the external oblique muscle in the direction of its fibers is visible. *This incision is always made through the* muscle fibers and never through the aponeurosis, which is located medially

E. The separated fibers of the external oblique muscle are retracted to expose the opening in the internal oblique muscle layer through which the underlying fibers of the transversus abdominis muscle are visible. *The* internal oblique is the thickest and the transversus abdominis is the thinnest of the *three muscle layers that are to be separated.*

F The muscle fibers of the internal oblique are separated by finger dissection, and care is observed to avoid avulsion of the underlying intercostal nerves between which an opening is made through the fibers of the transversus abdominis muscle. The dissection of this muscle is begun laterally and continued medially to lessen the possibility of opening into the peritoneal cavity The opening in this muscle layer exposes a portion of the irregular line of overlap of the retroperitoneal fat on the lateral parietal peritoneum.

G The muscle layers are retracted, and the transversalis fascia overlying the retroperitoneal fat is severed by scissor dissection. A herniation of a portion of the retroperitoneal fat through the opening made in the transversalis fascia is visible

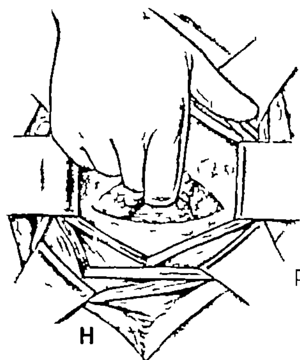
DISCUSSION—DR. GERALD H PRATT We have found spinal anesthesia not only safe, but one which, by its muscle relaxation, makes the operation technically easier The level of anesthesia must be to the fourth or fifth dorsal nerves. A hypobaric solution permits the operative area to be elevated at once. The patient is placed on the table at a 45 degree angle to the operator by placing a sandbag underneath the hip and shoulder The table is then broken, and the hand on the operator's side is raised high above the patient's head to pull the lower ribs out of the way In this position, the space between the last ribs and the crest of the ilium, which is normally only about 2 inches, can be widened to 4 or 5 inches, and the lumbar spine is brought quite close underneath the operative incision

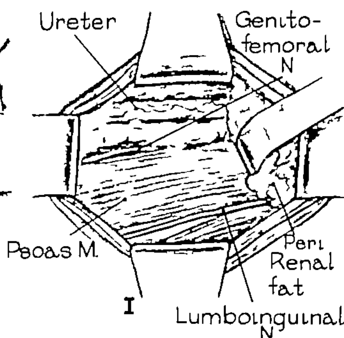
We use approximately the same incision for lumbar sympathectomy as the author a transverse one made in the line of the skin cleavage at the level of L 2 If the separation of the external oblique muscle the most restricting of the muscles, is extended longer than that through the other lateral abdominal muscles, the wound can be moved to excise a ganglion found anatomically higher or lower than usual.

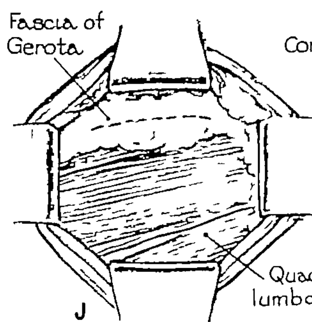
On the transversalis muscle and fascia lie the intercostal nerves and blood vessels. These nerves and vessels can be protected by making the transversalis incision between them, thus preserving the nerve supply to the muscles and also reducing the incidence of a painful neuritis. If the level of spinal anesthesia is slightly lower than desired, these nerves can be injected with procaine to avoid the addition of a general anesthesia, which we consider to be an added danger

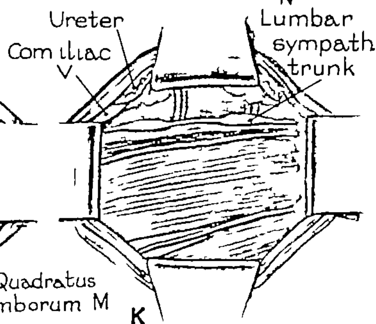
Mounted damp sponge sticks are adequate dissectors for moving the peritoneum and its contents forward without injury to the peritoneum One must avoid dissecting behind the iliacus or between the iliacus and the psoas muscles.

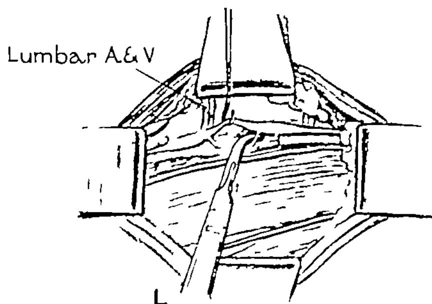
Any dissection of the vena cava must be gentle since its lumbar branches are thin and easily torn. We dissect the upper part of the chain first follow-


H


Ureter
Genito-
femoral
N
Psoas M.
Peri
Renal
fat
Lumboinguinal
N
I


Fascia of
Gerota
Quadratus
lumborum M
J


Ureter
Com iliac
V
Lumbar
sympath
trunk
K


Lumbar A& V
L

H. By blunt digital dissection in the retroperitoneal fat, the peritoneum and the adjacent intraperitoneal viscera are displaced toward the midline. During this dissection, the important landmark is the psoas major muscle, which is located more anteriorly than one generally assumes The tissue dissection is continued anteriorly and medial to this muscle otherwise, troublesome technical difficulty may ensue

I. The peritoneum and the related intraperitoneal viscera are retracted toward the mid line to expose the left ureter which overlies Gerota s fascia The ureter is always first identified before being retracted from the operative field. The adjacent related structures are readily demonstrable.

J The ureter is retracted medially The line of the incision to be made in the fascia of Gerota is indicated by the dotted line.

K. The incision in Gerota s fascia is completed, and, by blunt dissection with a long tissue forceps (deleted for clarity) in the underlying fatty areolar tissue, the lumbar sympathetic trunk and the lumbar vessels are exposed along the anterolateral surface of the vertebral column Further identification of the sympathetic trunk may be obtained by digital palpation against the sides of the lumbar vertebrae. The genitofemoral nerve frequently mistaken for the sympathetic trunk, may be seen coursing downward and lateralward along the medial aspect of the psoas muscle This nerve is white in color nonganglionated, easily mobile always on muscle (psoas), and directed downward and lateralward. Contrariwise, the lumbar sympathetic trunk is yellowish–white in color ganglionated, and located on the anterolateral aspect of the bodies of the lumbar vertebrae and never on muscle Furthermore, it is taut and relatively fixed in position by the attachment of the rami communicantes to their respective ganglia and is the most posteriorly situated structure along the vertebral column. Finally its direction is downward and slightly medialward. These anatomic differences should serve to differentiate the genitofemoral nerve from the lumbar sympathetic trunk.

L. The sympathetic trunk is mobilized on a nerve hook, and, with upward traction maintained, the anchoring rami communicantes are severed with a curved knife blade (No 12).

DISCUSSION—DR. PRATT (cont)

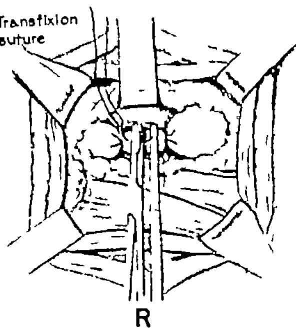
ing it as high as possible, usually to the diaphragm. To increase the extent of sympathectomy we avulse or exerese it from its surrounding tissue, and, if the pull on the chain is directly in the line of its fibers, the maneuver does not tend to lacerate any vessels.

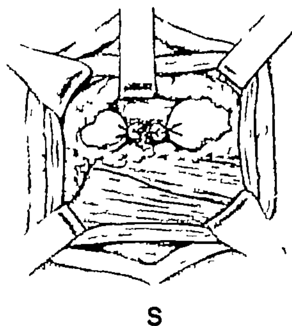
The so-called fool's sympathetic, the genitofemoral nerve, is seen lying on the muscle in contradistinction to the chain which is in close approximation to the periosteum of the vertebrae with its enlargements (ganglia) The chain has a characteristic feeling to the palpating finger We do not remove any structure as a chain until it is further identified manually by rubbing it against the vertebrae and feeling its cord, not unlike the vas deferens

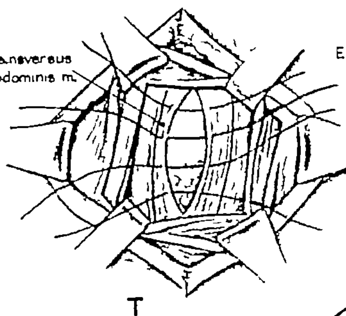
The artist s drawing depicts the sympathetic chain as a single nerve with ganglia More often it is found as a plexus of nerve fibers with several communicating branches entering the main trunk above and below the ganglia We feel it is important to remove all such fibers, even those that cross to the other side Thus the lumbar sympathetic nerves are a plexus and not just a nerve with ganglia There can be from two to eight ganglia in the lumbar area, and all the fibers should be removed in order to do a complete operation In many instances, a repeat lumbar sympathectomy has been effective, the preceding operation having only removed one or two ganglia with a continuation of sympathetic effect by collateral sympathetic nerves. Identification of the upper and lower ends of the resected sympathetic chain by a silver clip is practical, as the author has pointed out, and also prevents an annoying hemorrhage from an accompanying vessel. The author brings attention to the variations of the anatomy in the right and left sides and the danger of injuring vertebral veins. The removal of the underlying chain by dividing it at the overlying vein and teasing it under the vein is a safe measure, if done carefully While these lumbar veins can be clamped and divided, an attempt at their ligation is fraught with danger Serious complications have developed from trying to ligate small lumbar veins Silver clips are best used at this stage for hemostasis These veins in themselves are small, but they open directly into the vena cava. If these veins tear one has a laceration in the wall of the vena cava, and the small vein stump retracts and is a hole in the cava In cases of serious hemorrhage, packing is advisable at least until blood for transfusion is available This venous bleeding can be controlled by a hemostatic pack, while a laceration from traumatic tearing of a hastily applied clamp on the vena cava might be serious or even fatal.

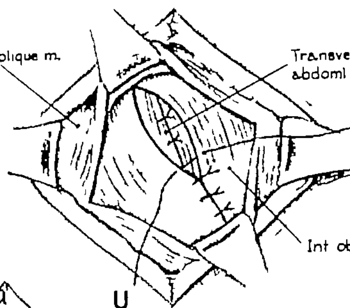
In closing the wound, one should again be careful to prevent inclusion of the nerves on the transver

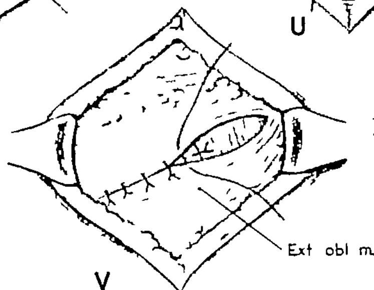
Plate 171

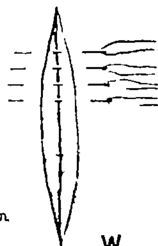

Transfixion
suture
R


S


Transversus
abdominis m.
T


Ext. oblique m.
Transve
abdomi
Int ob
U


Ext obl m.
V


W

REPAIR OF TRAUMATIC LACERATION OF THE INFERIOR VENA CAVA

The patient, a 39-year-old police officer shot by an assailant, was admitted to the hospital in shock Examination revealed a bullet wound of entrance below and to the right of the umbilicus and a wound of exit in the right loin. Replacement of blood loss and operation were done concomitantly There were two perforations in the small bowel and a large retroperitoneal hematoma on the right side The perforations were temporarily occluded with clamps, and the large retroperitoneal hematoma was evacuated. The lacerated wound *of the inferior vena cava was repaired as illustrated, and the intestinal wounds were closed* in layers (2) The postoperative convalescence of the patient was uneventful.

A. The patient is in the supine position, and the right paraumbilical incision is outlined. The bullet wound of entrance is indicated by the black circle.

B. The peritoneal cavity is entered, and the bulging retroperitoneal hematoma is visible Mobilization of the right colon is begun by scissor dissection along the fascia fusion layer of Toldt, the "white line"

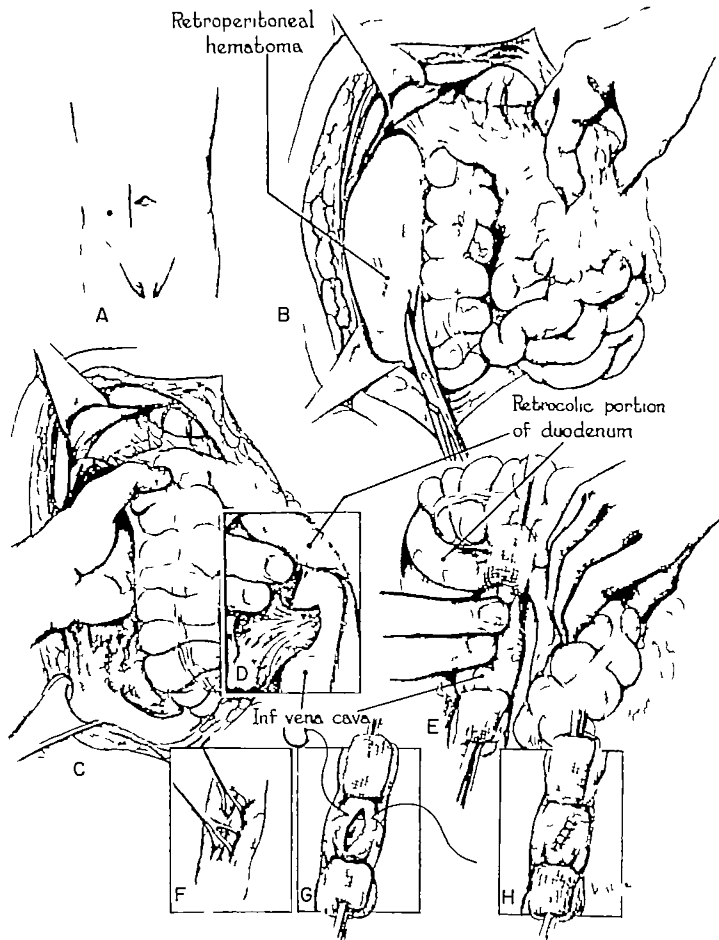
C. Mobilization of the right colon is continued by digital dissection. The subsequent severance of the phrenocolic ligament to free the hepatic flexure is indicated by the broken line cephalad. The clotted blood retroperitoneally (caudad) is also visible

D E, F Following decompression of the retroperitoneal space by the evacuation of large quantities of clotted blood, active bleeding from the traumatic laceration in the inferior vena cava ensued (D) The bleeding was immediately controlled by digital compression (E) The "blind" application of clamps for hemostasis is dangerous and should be judiciously avoided Large pledgets of dry gauze secured in clamps, are used to compress the inferior vena cava both cephalad and caudad to the site of digital compression The fingers are removed, and the margins of the laceration in the inferior vena cava are approximated with clamps * (Babcock) modified on the Potts principle (F)

G, H. Gauze compression of the inferior vena cava is maintained as the clamps are removed (G) and the lacerated wound is closed using interrupted sutures of 00000 arterial silk (G H)

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* Manufactured by Edward Weck & Co., Long Island City N Y


Retroperitoneal hematoma
A
B
Retrocolic portion of duodenum
C
D
Inf vena cava
E
F
G
H

CIRCUMFERENTIAL VENOUS LIGATION FOR POSTPHLEBITIC ULCER

A. Palpation of a "feeder" vein subjacent to the ulcer

B. The incisions in relation to the ulcer are shown and the lowermost is being deepened through the underlying indurated tissue.

C. The "feeder" vein is isolated

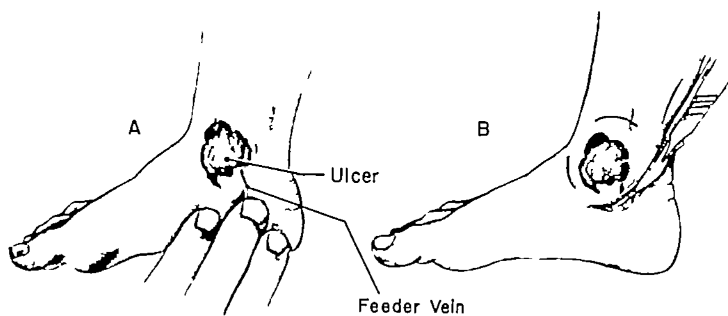
D It is doubly ligated in continuity and severed.

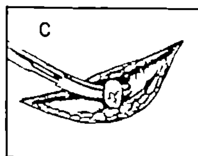
E. The operation is completed. The wounds, rather than being sutured, are packed loosely with sterile dry gauze and a compression dressing is applied.

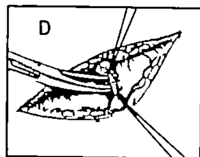
DISCUSSION—DR. JOHN L. KEELEY The operation described by Dr Madden appears to offer a promising solution for a very troublesome lesion. His results justify its further trial as it is a procedure that in the past has not been as helpful in the hands of others. If an ulcer such as that illustrated is dependent upon venous stasis alone, interruptions of the neighboring veins as described should be beneficial However many will be associated with postphlebitic induration in the surrounding blood-poor tissues, such as fat, ligaments, tendons, and periosteum In patients with normal tissues healing is slower in the region of the ankle than at higher levels. This is well illustrated in the healing of incisions at the ankle level compared to those which take place at higher levels in the ligation and stripping of varicose veins uncomplicated by previous cellulitis. The ankle is near the end of the "blood supply line." If arteriosclerosis is also present, one hesitates to cut off blood supply coming to an ulcerated area through vessels in the skin or immediately under it by partially surrounding the ulcer with incisions. Patients with either ulcer or postphlebitic induration should be warned of the vulnerable status of tissues in the areas so characteristically involved. Trauma to the region, whether surgical or accidental, may be followed by ulceration or slow healing.

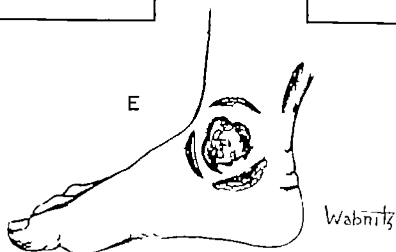
One wonders if the postoperative care following circumferential venous ligation is more carefully planned and executed than that ordinarily accorded the patient with an ulcer not subjected to a surgical procedure Attention paid to cleanliness and asepsis and to effective support for the area may contribute significantly to the good results the author has attained

It seems reasonable that the patient with an ulcer about which "feeder" veins may be demonstrated and with minimal evidence of postphlebitic cellulitis might be treated by this procedure on a trial basis In some patients it may suffice. If it fails, the more formidable operations of fasciectomy and individual ligation of perforating communicating veins, with or without skin grafting, may be needed.


A
B
Ulcer
Feeder Vein


C


D


E
Wabnitz

SPLENECTOMY AND END TO SIDE SPLENORENAL SHUNT

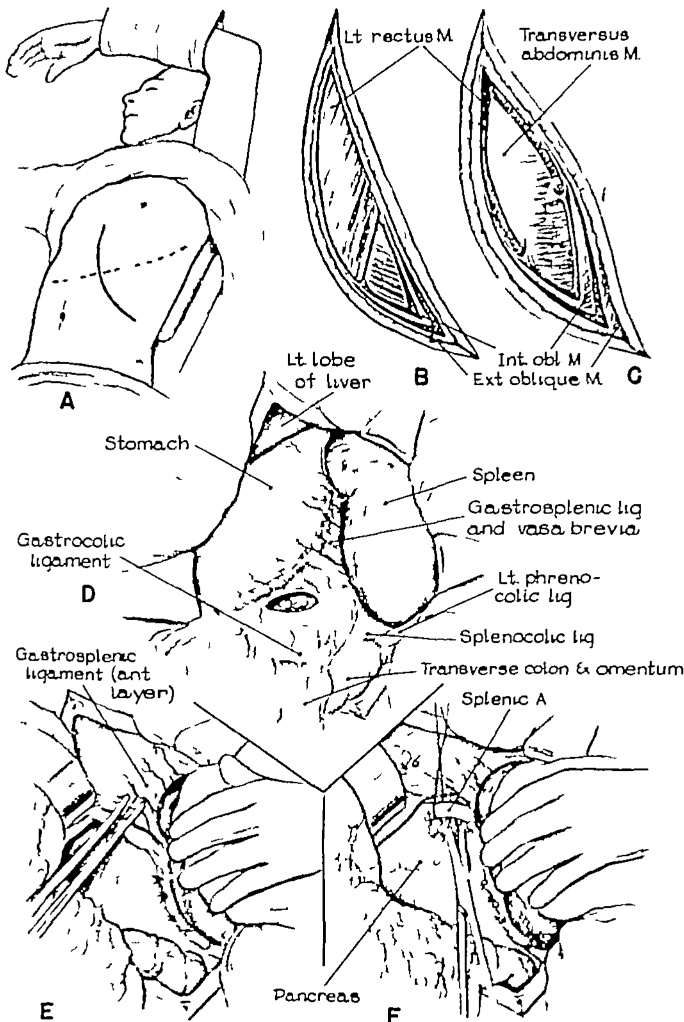
A. The patient is placed in the supine position, and the left side is elevated on a pillow support to approximately a 30 degree angle from the horizontal The incisions of choice, a long curvilinear subcostal incision solid line) that extends from the left costophrenic angle to the posterior axillary line, and an abdominothoracic incision (dotted outline) that enters the left pleural cavity through the eighth interspace, are shown. In this particular patient, the subcostal incision was used.

B C. The incision is deepened through the rectus sheath, the underlying fibers of the rectus abdominis, the external oblique, and the internal oblique muscles to expose the transversus abdominis muscle and its aponeurosis.

D The peritoneal cavity is entered, and the relation of the enlarged spleen to the surrounding structures is depicted. An opening is made in an avascular segment of the gastrocolic ligament preliminary to the serial clamping and severance of its proximal extension, the anterior layer of the gastrosplenic ligament.

E. The mobilization of the spleen is continued by doubly clamping and cutting (dotted line) the anterior layer of the gastrosplenic ligament and its contained vasa brevia.

F The superior border of the pancreas is exposed, and the splenic artery is encircled by a ligature of silk (00) for traction as mobilization of the artery is completed by scissor dissection. A second ligature of silk (00) is subsequently inserted, and double ligation, in continuity of the splenic artery is performed.

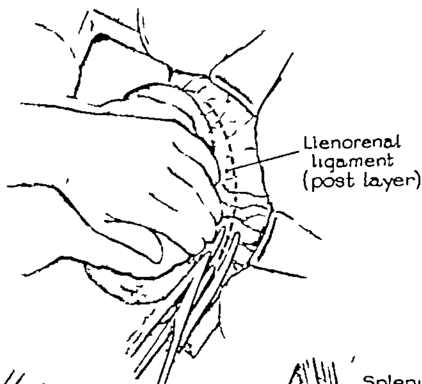

Lt rectus M
Transversus abdominis M
Int obl M
Ext oblique M
A
B
C
Lt lobe of liver
Stomach
Spleen
Gastrosplenic lig and vasa brevia
Gastrocolic ligament
D
Lt. phreno-colic lig
Splenocolic lig
Gastrosplenic ligament (ant layer)
Transverse colon & omentum
Splenic A
Pancreas
E
F

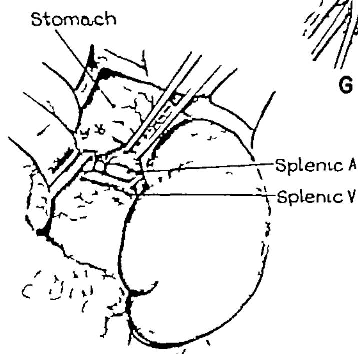
G The spleen is manually rotated and displaced toward the midline, and the reflection of the posterior parietal peritoneum forming the posterior layer of the lienorenal ligament is severed under direct vision by scissor dissection Normally this ligament is avascular However in the presence of portal hypertension the application of clamps to this ligament is frequently required to prevent excessive blood loss from the extensive collateral vascular bed.

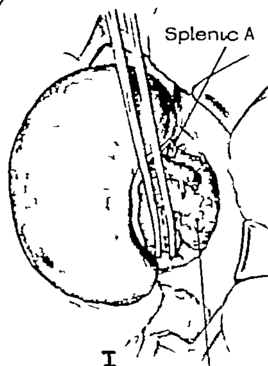
H. The spleen is reposited laterally and the superior segment of the gastrocolic ligament is doubly clamped and severed (dotted line). This segment is the narrowest portion of the gastrosplenic ligament, and particular care should be observed in the application of clamps to prevent injury to the greater curvature of the stomach Furthermore, one of the largest of the vasa brevia is contained in this narrow uppermost portion of the gastrosplenic ligament in relation to the superior pole of the spleen. Accordingly in the mobilization of the superior pole of the spleen, one should proceed with caution to avoid an avulsion laceration of this vessel and resulting hemorrhage

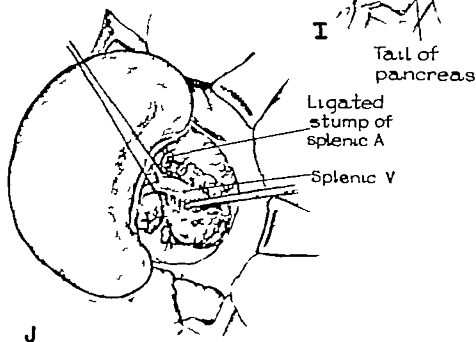
I. Following the completion of the severance of the anterior layer of the gastrosplenic ligament, the spleen is again rotated toward the midline and the pad of vascular areolar tissue in relation to the inferior pole of the spleen and the tail of the pancreas is doubly clamped prior to its severance.

J The splenic vein in the hilum of the spleen is encircled with a traction ligature of silk (00), and the vein is mobilized by clamping and dividing the pancreatic tributary veins as indicated


Llenorenal
ligament
(post layer)
G


Stomach
Splenic A
Splenic V
H


Splenic A
I
Tail of
pancreas


Ligated
stump of
splenic A
Splenic V
J

K. The mobilized segment of the splenic vein is doubly clamped using both angulated and straight Potts ductus clamps The site for transection of the vein, in juxtaposition to its bifurcation at the hilum of the spleen, is indicated by dotted lines. The incision in the anterior layer of the renal fascia for the exposure and subsequent mobilization of the kidney is also indicated in dotted out line

L. The left kidney is mobilized from its surrounding adipose capsule and rotated toward the midline The relation of the kidney to the left adrenal gland and the surrounding structures is visible

M The mobilized kidney is rotated laterally and posteriorly and the distal segments of the renal artery and vein are mobilized by a combination of blunt and sharp dissection. The renal vein is encircled by cotton traction tapes to facilitate its manipulation.

N. The lumen of the renal vein is partially occluded by a Potts–Smith clamp and the proximal cut end of the splenic vein is turned down toward the incised opening in the renal vein preparatory to the anastomosis

DISCUSSION—DRS. ARTHUR H BLAKEMORE AND ARTHUR B VOORHEES, JR The position of the patient on the operating table, the location and technic of the incision are similar to those described in *Portal vein to-vena cava anastomosis*, with the exception that all takes place on the left rather than the right side of the patient (Fig. 1).

When the operative incision and general abdominal examination have been completed, manometric pressures in the portal system are recorded by the described technic. A liver biopsy is obtained in the described fashion however in this case it is usually obtained from the left lobe rather than the right lobe of the liver

At this point the operation can be divided into three steps for sake of convenience of description. The first step is the mobilization and subsequent resection of the spleen. The second step is the identification and mobilization of the splenic vein, and the third step is the performance of an end to-side anastomosis between the splenic vein and the left renal vein.

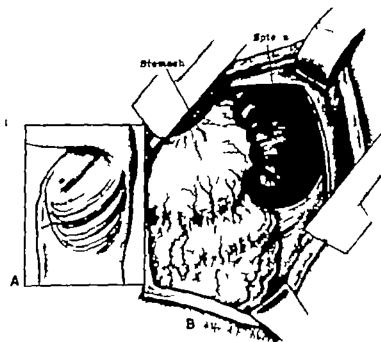
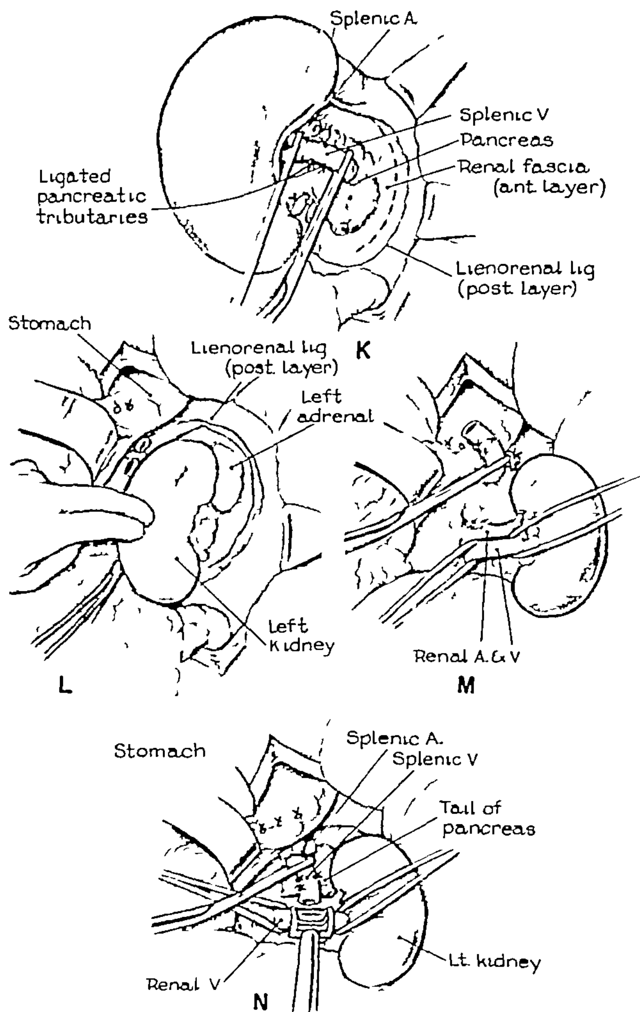


Fig 1 A. line of incision, B. illustrating exposure following completion of a thoracoabdominal approach Note that splitting the diaphragm affords direct access to control of hemorrhage in separating an adherent spleen from the diaphragm


Splenic A.
Splenic V
Pancreas
Renal fascia (ant. layer)
Ligated pancreatic tributaries
Lienorenal lig (post. layer)
K
Stomach
Lienorenal lig (post. layer)
Left adrenal
Left kidney
Renal A. & V
L
M
Stomach
Splenic A.
Splenic V
Tail of pancreas
Lt. kidney
Renal V
N

O, P Q R. Close up illustrations to show more clearly the technic of the anastomosis of the proximal cut end of the splenic vein to the longitudinal opening in the side of the left renal vein.

O P The posterior suture layer is inserted. This is a continuous eversion suture of 00000 arterial silk on a swedged-on minimum trauma needle The suture is commenced from the "outside in" on the splenic vein and terminates from the "inside out" on the same vein. Between its commencement and termination, the suture is inserted alternately from the "inside out" to the "outside in" on the renal and splenic veins respectively Accordingly the loop is on the outside of the lumen, and, when the suture is drawn taut, it causes an eversion of the tissues with intima to intima approximation.

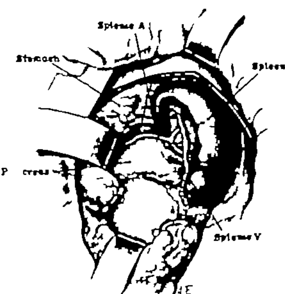
Q The anterior layer of the anastomosis consists of a series of interrupted everting mattress sutures of silk (00000) These sutures are all inserted, and the end sutures are tied. One of the strands of each of the end mattress sutures is then tied to either end of the continuous everting posterior suture (a–a).

R. The completed anterior layer of the anastomosis prior to the release of the Potts-Smith clamp is shown

S. The completed end to-side splenorenal shunt and its relation to the surrounding structures is illustrated

Discussion—Drs. Blakemore and Voorhees (cont.)

Step I (Figs. 2 and 3) The gastrolienal and lienocolic ligaments are divided. The anterior rim of the spleen is rotated laterally in order to expose the hilar structures. The splenic artery is identified and doubly ligated proximal to its subdivision. The splenic vein is identified and gradually mobilized by sharp dissection to the hilus of the spleen. A rubbershod noncrushing clamp is applied as the splenic vein goes beneath the tail of the pancreas, and a crushing clamp is applied to the splenic vein as it emerges from the hilum. The vein is transected, and the spleen is removed after division of its diaphragmatic attachments.



F g 2 Exposure of short gastric vessels, splenic artery and splenic ein

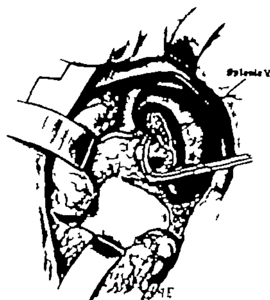
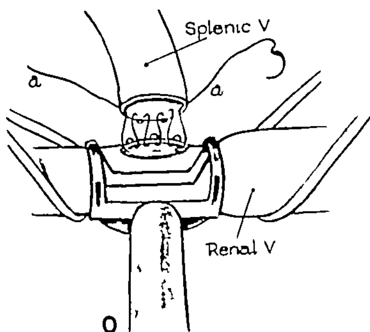
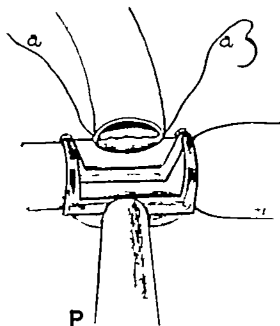
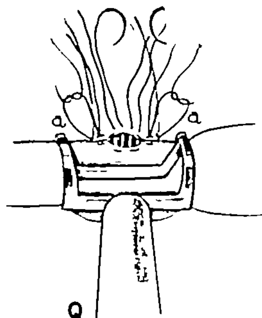
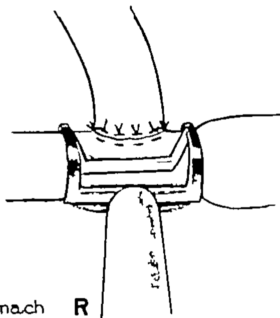


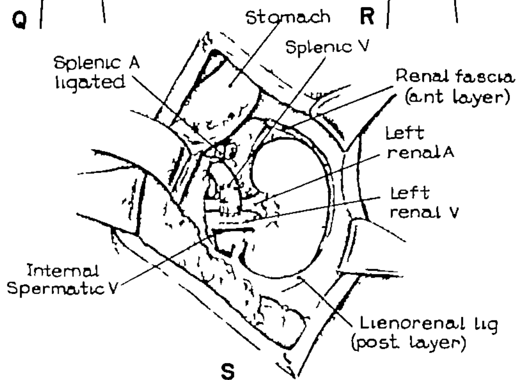
Fig 3 A rubbershod clamp has been placed on the splenic vein, and it is ready for section well distal to the clamp


Splenic V
a
a
Renal V
O


a
a
P


a
a
Q


R


Stomach
Splenic V
Splenic A ligated
Renal fascia (ant layer)
Left renal A
Left renal V
Internal Spermatic V
Lienorenal lig (post. layer)
S

DISCUSSION—DRS BLAKEMORE AND VOORHEES (cont.)

Step 2 (Figs. 4 and 5). The noncrushing rubber shod clamp compressing the stump of the splenic vein is released for an instant to allow a rush of venous blood through the splenic vein stump to carry away any clot which may have formed in the splenic vein during the course of the splenectomy Following this, the rubbershod clamp is reapplied, and 20 ml. of a dilute heparin–saline solution are injected into the splenic vein stump proximal to the point of compression by the clamp. The vein is retracted forward, and a usually incomplete collar of pancreatic tissue is divided between clamps along the posterior aspect of the splenic vein stump. Following the division of this areolar and pancreatic tissue for a distance of approximately 3 cm parallel to the posterior aspect of the splenic vein stump, the tail of the pancreas is drawn forward, and the splenic vein is drawn laterally The splenic vein is gradually dissected free from the overlying tail of the pancreas. During this last maneuver it is exceedingly important to identify and to transfix with 00000 braided arterial silk the numerous, tenuous, venous tributaries entering the splenic vein from the tail of the pancreas. If these veins are placed under too much traction, they will tear at their juncture with the splenic vein, and the subsequent repair of the tear in the splenic vein will compromise the lumen and subsequently jeopardize the efficiency of the shunt. The mobilization of the splenic vein stump is carried medially to the point where the inferior mesenteric vein joins the splenic vein.

Step 3 (Fig. 6). The peritoneum overlying the left kidney is incised over the hilus of the kidney This initial line of incision is bisected by a similar peritoneal incision running parallel to the left renal vein. The renal vein is gradually mobilized over a distance of approximately 3 cm. midway between the hilus of the kidney and the vena cava. Two major venous

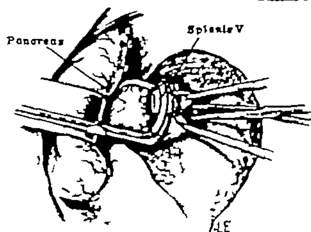


Fig 4 Illustrates beginning mobilization of splenic vein

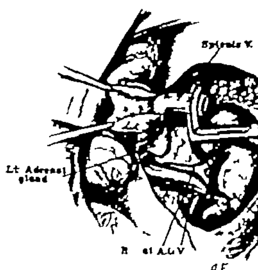


Fig 5 Displays the mobilized stump of the splenic vein Note the tunnel between the left adrenal gland and the upper pole of the left kidney the result of removing retroperitoneal fat.

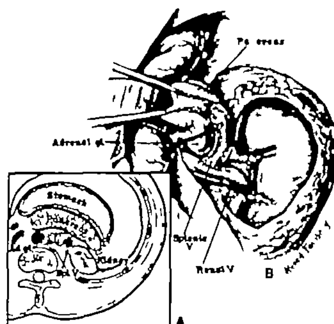


Fig 6 B an illustration of the completed splenorenal shunt. Note in cross-section illustration A that the splenic vein rests in a deep sulcus between the left adrenal gland and the upper pole of the kidney out of harm's way from compression by the pancreas

Discussion—Drs. Blakemore and Voorhees (cont)

tributaries, the left spermatic (or ovarian) vein and the adrenal vein, should be identified and preserved where possible. However if the preservation hampers subsequent anastomosis, both may be ligated with impunity After clearing the renal vein, the left adrenal gland and its vascular supply are identified, and the adrenal gland is pushed medially by dividing its adventitial attachment to the kidney capsule. By pushing the adrenal gland medially a sulcus can be developed between the adrenal gland and the upper pole of the left kidney which will subsequently accommodate the splenic vein and offer it protection from subsequent compression by the overlying pancreas. We feel that the development of this protected channel is of utmost importance By trial placements of the splenic vein stump, a suitable site for end to-side anastomosis with the renal vein is selected so that an anastomosis of maximum obliquity between the splenic vein and the renal vein can be achieved. It is desirable that the splenic vein and the renal vein form an acute angle of roughly 60 degrees. After selection of the site of anastomosis, marking stay sutures are placed in the renal vein, and the vein is tented and grasped by a Beck Potts clamp An end to-side anastomosis is achieved in precisely the same fashion as that described for the portacaval shunt, with the exception that, in children where growth is expected, interrupted horizontal mattress sutures are employed in the anterior row of the anastomosis instead of the continuous over and over everting suture. Following completion of the anastomosis, the clamps are removed and the shunt is carefully examined for deformities which may compromise the efficiency of the shunt. The pancreatic tail is allowed to resume its natural position. Portal pressures are again taken, with and without splenic vein compression, to test the efficiency of the shunt. The splenic flexure of the colon is allowed to fall into place and no effort is made to reperitonize the operative area. The abdominal and thoracic wounds are closed in similar manner to that described for the portal vein to-vena cava shunt.

DISCUSSION—DR. C STUART WELCH The indications for the use of an anastomosis from splenic vein to renal vein instead of a direct portacaval shunt have diminished greatly in the past ten years. In our hospital today we seldom perform splenectomy and splenorenal shunt. Splenorenal shunt had its vogue because technically it seemed to be a less dangerous procedure than portacaval shunt. That is to say it avoided dissection in the hepatic pedicle, where injury to the common bile duct, hepatic artery and indeed the portal vein itself might occur With increasing experience with the right-sided operation (portal vein to vena cava shunt) it became apparent that splenorenal anastomosis was more difficult and time-consuming than was a portacaval anastomosis. But, most important, the rate of recurrent bleeding from esophageal varices directly caused by thrombosis or closure of the splenorenal shunt was found to be high—much higher than in portacaval shunts when late results were evaluated (30 per cent for the former as contrasted to 2 per cent or less for the latter)

The reason for the high rate of splenorenal shunt failures is technical The splenic vein is smaller than the portal vein. Furthermore, angulation and slowing of the current of shunted blood can occur encouraging clotting. Splenorenal anastomosis is a rather awkward shunt.

As an indication for the use of splenectomy and splenorenal shunt, most surgeons accept the absence of a useful portal vein, as is found in extrahepatic portal hypertension due to congenital or acquired obliteration of the portal vein as a prime indication. The one difficulty with using splenorenal anastomosis in such cases is that variceal bleeding occurs in very young patients with extrahepatic bed block. In these patients the splenic vein is often so small as to invite anastomosis failure if it is used Experience has shown that splenorenal anastomosis is doomed to failure in the very young. It is only when the child passes 10 years of age that a good sized splenic vein can be a reasonable hope Even then the site for splenic vein anastomosis must be as near the portal vein as possible to secure a good lumen. Bleeding from varices in the very young can be temporarily controlled by such expediencies as small esophagogastric resection and jejunal or colonic interposition. This operation has more success than simple ligation of esophageal varices. By employing methods for the temporary control of bleeding, the child grows in the meantime and there is hope that a large splenic vein will be found and a satisfactory splenic renal vein decompression can be fashioned

The remark made above about the indications for splenorenal shunt must be taken with some reservation now that another alternative shunt has been found to be useful in the very young This is the Marion Shunt which is performed by anastomosis of the cephalad cut end of the vena cava below the renal veins to the side of the superior mesenteric vein The technic of this shunt is not part of the present discussion. Suffice it to say that its employment as thus far reported indicates that a more substantial shunt can be performed by the Marion technic than by the splenorenal method and that, therefore the indications for splenorenal shunts are again lessened.

Another indication for splenectomy and splenorenal shunt is said to exist when a large spleen with a blood dyscrasia exists. Such blood dyscrasias are usually mild pancytopenias when found in patients with cirrhosis of the liver and congestive splenomegaly Unless the dyscrasia is severe (and it is rarely so) a direct portacaval shunt should be the procedure of choice because of its greater efficiency in controlling portal hypertension In 80 per cent of patients with pancytopenia, portacaval shunts result in shrinking of the size of the spleen and return of the cellular elements of the blood to normal or near normal In the other 20 per cent only mild dyscrasias of no clinical importance persist If splenectomy is needed because of a persistent dyscrasia, it can be done later I have never had to do a secondary splenectomy

In short, while it can be said that the above indications (blood dyscrasias) for splenectomy and splenorenal shunt exist, seldom need this procedure be applied. Since the hematologist may demand it, however it must be done occasionally

In regard to the technic of splenectomy and splenorenal anastomosis depicted in the illustrations, there is some area for disagreement although the variation which I will point out may be personal

At any rate, in reference to A, B, and C, I offer the following comments. I believe that the thoracoabdominal incision is the best choice for this procedure, and I normally use it. I hold the opposite view for portacaval shunt (abdominal exposure only) Exposure is much more adequate with a left thoracoabdominal incision than a subcostal incision, both for the performance of the dissection and the shunt. There may be very troublesome bleeding to control during the operation of splenectomy and splenorenal shunt in the following instances Vascular adhesions of the spleen to the diaphragm are often troublesome. Large and multiple retroperitoneal collaterals from the spleen, particularly laterally may be difficult to manage without a large exposure. Pancreatic tributaries of the splenic vein must be carefully dissected and ligated to prevent abnormal blood loss. Finally dissection in and about the kidney pedicle is facilitated by the thoracoabdominal exposure. Therefore, I always make a thoracoabdominal incision when I perform a splenorenal shunt.

In reference to D E, and F I would like to comment on the matter of preliminary ligation of the splenic artery It is true that splenic artery ligation helps control bleeding from the spleen and its collaterals during its mobilization and removal but I believe that it is not a necessary preliminary step I prefer to perform step G (lateral mobilization of the spleen) first and do not ligate the splenic artery unless bleeding is excessive My reason for doing so is that a large full splenic vein is more easily dissected

As Dr Madden points out, injury to the stomach in detaching it from the spleen is possible, particularly high on the greater curvature at the superior pole of the spleen, where the stomach is in contact with the spleen and the false application of a clamp or ligature on the greater curvature of the stomach can result in necrosis and subsequent gastric fistula with peritonitis.

I, J and K, would indicate that dissection of the

DISCUSSION—DR. WELCH (cont.)

splenic vein is done posteriorly after mobilization of the spleen and rotating it medially. I do not believe that this technic can be carried out satisfactorily. Mobilization of the splenic vein is best done anteriorly with the spleen in nearly its usual position. The splenic vein is actually partially imbedded in the pancreas. Securing all of the small intrapancreatic tributaries is the important feature of this step.

L, M, N, O, P, Q, R, and S deal with mobilization of the kidney and the actual anastomosis of the end of the splenic vein to the side of the renal vein partially occluded in a Potts-Smith clamp. This would seem to be a good technique employing the everting suture anastomosis. If the renal vein is large, an oval opening can be made in the occluded segment. This is said to make the anastomosis less "slitlike" and less likely to close. A transverse opening in the renal vein may also be made. It tends to gape and stay open, which lessens the likelihood of anastomotic thrombosis. Such an incision requires that the blood supply to the kidney be occluded during the anastomosis. This is done by putting a bull dog clamp on the renal artery to occlude temporarily its blood supply. The actual time needed to complete a splenorenal anastomosis is approximately 20 minutes, which is readily tolerated by the kidney. I have used temporary renal artery occlusion during splenorenal anastomosis in many patients without permanent damage to the kidney as judged by postoperative intravenous pyleograms. This technique is particularly useful when the application of a clamp to partially occlude the renal vein is difficult and awkward.

DISCUSSION—DR. LOUIS M. ROUSSELOT. Portasystemic shunts are primarily indicated for the relief of gastroesophageal hemorrhage by lowering the portal tension in the syndrome of portal hypertension. Dr. Madden's preference is a direct end-to-side portocaval shunt rather than a splenorenal shunt. It is my opinion that a splenorenal shunt be reserved for those cases in which the former is not feasible—i.e., an extrahepatic portal vein block, either congenital or acquired.

The incisions illustrated in A represent standard approaches. The combined thoracoabdominal incision (*broken line*) *gives the optimal exposure.* With the combined approach, the abdominal component should be initially opened to confirm the diagnosis and establish operability. An unsuspected hepatoma or a secondary malignant disease that obstructs the portal bed may be established, a biopsy taken, and the operation terminated forthwith.

In the presence of inflammatory pulmonary disease, the incision should be limited to the abdomen. Besides the subcostal incision shown in A, a long transverse incision from the midline well out to the flank may be substituted.

The operative steps in A through S are clearly illustrated with exactitude. Certain admonitions and variations are presented. Rarely should blunt dissection be attempted in any operation for portal hypertension. The relatively avascular organ attachments found in other disease states are not present in portal hypertension. Extensive collateralization is regularly found in the splenocolic ligament (D), the gastrosplenic ligament (E), and the lienorenal ligament (G). Furthermore, highly vascular adhesions usually envelop the spleen and fix it to the diaphragm and the lateral parietal peritoneum. These should be serially clamped, severed, and ligated. Blunt dissection is extremely hazardous and may be accompanied by severe blood loss (G).

D through J represent the exposure of the true pedicle from its lateral and posterior aspects. An alternate method is to expose the pedicle from its anterior surface, medial to the splenic hilum. The steps depicted in D through H are followed as shown. At this juncture, several moist laparotomy pads are inserted into the splenic "bed" in the subphrenic space, and the spleen is displaced downward and forward. The arterial ligation is completed as shown in H. However, the mobilization of the splenic vein proceeds from the anterior surface of the pedicle as in H, rather than rotating the spleen and continuing the dissection as demonstrated in I, J, and K.

Upon completion of the exposure of the pedicle of the left kidney, I find it desirable to identify early the ureter and to "tab" it with cotton tape, similar to the manner in which the renal vein is "*tabbed*" *in M. Occasionally limitations of exposure* make the use of short, spring "bulldog" clamps preferable to the long handle Potts ductus clamps shown in K. Individual preference may again call for a modification in technic. The Glover auricular clamp or Satinsky clamp is in my opinion a more versatile instrument than the Potts-Smith clamp used in N. A greater surface area of the renal vein may be occluded, which permits the surgeon a wider clearance between the edge of the new stoma and the margin of the occlusive clamp. The cutting of an oval opening in the side wall of the renal vein rather than making a linear incised wound as indicated (N) is again an alternative step. This facilitates the suture anastomoses and minimizes late stenosis or closure of the stoma site.

In O through S, several modifications are permissible. Instead of using interrupted sutures in the anterior layer (Q) a continuous suture may be used, like that shown for the posterior layer (O). In children interrupted sutures are probably preferable for both the posterior and the anterior layers, to compensate for the increase in the size of the vessels during growth and accordingly to prevent decrease in size of the stoma. Instead of the "everting" type of sutures depicted (O, Q), a continuous noneverting suture, interrupted only at the angles of the anastomosis, may be used both anteriorly and posteriorly. Furthermore, if desired, additional "stay" sutures may be inserted at each angle prior to the insertion of the continuous sutures forming the anterior and posterior layers of the anastomosis.

DISCUSSION—DR. C. STUART WELCH The indications for the use of an anastomosis from splenic vein to renal vein instead of a direct portacaval shunt have diminished greatly in the past ten years. In our hospital today we seldom perform splenectomy and splenorenal shunt. Splenorenal shunt *had its vogue because technically it seemed to be* a less dangerous procedure than portacaval shunt. That is to say it avoided dissection in the hepatic pedicle, where injury to the common bile duct, hepatic artery and indeed the portal vein itself might occur With increasing experience with the right-sided operation (portal vein to vena cava shunt) it became apparent that splenorenal anastomosis was more difficult and time-consuming than was a portacaval anastomosis. But, most important, the rate of recurrent bleeding from esophageal varices directly caused by thrombosis or closure of the splenorenal shunt was found to be high—much higher than in portacaval shunts when late results were evaluated (30 per cent for the former as contrasted to 2 per cent or less for the latter)

The reason for the high rate of splenorenal shunt failures is technical. The splenic vein is smaller than the portal vein Furthermore, angulation and slowing of the current of shunted blood can occur encouraging clotting. Splenorenal anastomosis is a rather awkward shunt.

As an indication for the use of splenectomy and splenorenal shunt, most surgeons accept the absence of a useful portal vein as is found in extra hepatic portal hypertension due to congenital or acquired obliteration of the portal vein as a prime indication. The one difficulty with using splenorenal anastomosis in such cases is that variceal bleeding occurs in very young patients with extra hepatic bed block. In these patients the splenic vein is often so small as to invite anastomosis failure if it is used Experience has shown that splenorenal anastomosis is doomed to failure in the very young. It is only when the child passes 10 years of age that a good sized splenic vein can be a reasonable hope. Even then the site for splenic vein anastomosis must be as near the portal vein as possible to secure a good lumen. Bleeding from varices in the very young can be temporarily controlled by such expediencies as small esophagogastric resection and jejunal or colonic interposition. This operation has more success than simple ligation of esophageal varices. By employing methods for the *temporary control of bleeding, the child grows in* the meantime and there is hope that a large splenic vein will be found and a satisfactory splenic renal vein decompression can be fashioned.

The remark made above about the indications for splenorenal shunt must be taken with some reservation now that another alternative shunt has been found to be useful in the very young. This is the Marion Shunt, which is performed by anastomosis of the cephalad cut end of the vena cava below the renal veins to the side of the superior mesenteric vein The technic of this shunt is not part of the present discussion Suffice it to say that its employment as thus far reported indicates that a more substantial shunt can be performed by the Marion technic than by the splenorenal *method and that, therefore, the indications for* splenorenal shunts are again lessened.

Another indication for splenectomy and splenorenal shunt is said to exist when a large spleen with a blood dyscrasia exists. Such blood dyscrasias are usually mild pancytopenias when found in patients with cirrhosis of the liver and congestive splenomegaly Unless the dyscrasia is severe (and *it is rarely so) a direct portacaval shunt should* be the procedure of choice because of its greater efficiency in controlling portal hypertension. In 80 per cent of patients with pancytopenia, portacaval shunts result in shrinking of the size of the spleen and return of the cellular elements of the blood to normal or near normal. In the other 20 per cent only mild dyscrasias of no clinical importance persist If splenectomy is needed because of a persistent dyscrasia, it can be done later I have never had to do a secondary splenectomy

In short, while it can be said that the above indications (blood dyscrasias) for splenectomy and splenorenal shunt exist, seldom need this procedure be applied. Since the hematologist may demand it, however it must be done occasionally

In regard to the technic of splenectomy and splenorenal anastomosis depicted in the illustrations, there is some area for disagreement although the variation which I will point out may be personal.

At any rate, in reference to A, B and C, I offer the following comments. I believe that the thoracoabdominal incision is the best choice for this procedure, and I normally use it. I hold the opposite view for portacaval shunt (abdominal exposure only) Exposure is much more adequate with a left thoracoabdominal incision than a subcostal incision, both for the performance of the dissection and the shunt. There may be very troublesome bleeding to control during the operation of splenectomy and splenorenal shunt in the following instances. Vascular adhesions of the spleen to the diaphragm are often troublesome. Large and multiple retroperitoneal collaterals from the spleen, particularly laterally may be difficult to manage without a large exposure. Pancreatic tributaries of the splenic vein must be carefully dissected and ligated to prevent abnormal blood loss. Finally dissection in and about the kidney pedicle is facilitated by the thoracoabdominal exposure. Therefore, I always make a thoracoabdominal incision when I perform a splenorenal shunt.

In reference to D E, and F I would like to comment on the matter of preliminary ligation of *the splenic artery It is true that splenic artery ligation* helps control bleeding from the spleen and its collaterals during its mobilization and removal but I believe that it is not a necessary preliminary step I prefer to perform step G (lateral mobilization of the spleen) first and do not ligate the splenic artery unless bleeding is excessive. My reason for doing so is that a large full splenic vein is more easily dissected.

As Dr Madden points out, injury to the stomach in detaching it from the spleen is possible, particularly high on the greater curvature at the superior pole of the spleen, where the stomach is in contact with the spleen and the false application of a clamp or ligature on the greater curvature of the stomach can result in necrosis and subsequent gastric fistula with peritonitis.

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Discussion—Dr. Welch (cont)

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F The mobilized hepatic flexure of the colon is displaced downward toward the left lower quadrant of the peritoneal cavity and the foramen of Winslow, the pylorus, the head of the pancreas, and the retrocolic portion of the duodenum are exposed Mobilization of the descending portion of the duodenum is commenced by scissor dissection of the posterior parietal peritoneal layer along its lateral border (Kocher maneuver). Normally this peritoneal layer like the posterior layer of the lienorenal ligament, is avascular and may be severed with impunity However in the presence of portal hypertension, the application of clamps to prevent excessive blood loss may be required.

The mobilization of the duodenum as depicted is no longer practiced This maneuver was often associated with unnecessary blood loss and prolongation of the operation Instead, dissection of the portal vein is immediately commenced and is then followed by mobilization of the inferior vena cava.

G The mobilized segment of the duodenum and the head of the pancreas are retracted toward the midline to expose the related structures as depicted

H. The dissection is continued, and the structures are now more clearly visualized. The dissection and isolation of the structures shown is both tedious and difficult because of the edema and increased vascularity of the tissues. The mobilized segment of the inferior vena cava is encircled by a traction tape of rubber tissue and partially retracted to expose clearly the group of lymph nodes between the aorta and the inferior vena cava.

I. The portal vein is occluded, first proximally with an angulated Potts ductus clamp and then distally with a ligature and a suture ligature of silk (00) respectively The site for transection of the portal vein is indicated in dotted outline The convergence cephalad of the portal vein and the inferior vena cava and their separation by the caudate process of the liver may be readily seen. In some instances, partial resection of an enlarged caudate process, as suggested by Blakemore, may be required to permit the performance of a portacaval shunt

DISCUSSION—DRS BLAKEMORE AND VOORHEES (cont.) the bed of the ninth rib, including the diaphragmatic pleura and peritoneum, and splitting the diaphragm in the course of its muscle fibers for approximately 12 to 15 cm. After general abdominal examination and confirmation of the diagnosis, a specimen for biopsy is obtained from the right lobe of the liver by making a cruciate incision through the liver capsule on the anterior margin and inserting a cork borer of approximately 5 mm. in diameter to the depth of 4 cm. The plug of liver tissue thus obtained is immediately given to the pathologist for early fixation. Bleeding from the biopsy site is controlled by suitably placed mattress sutures tied over a plug of skeletal muscle.

For the sake of convenience, the subsequent operative procedure can be divided into three parts. The first step is that of mobilization of the duodenum and

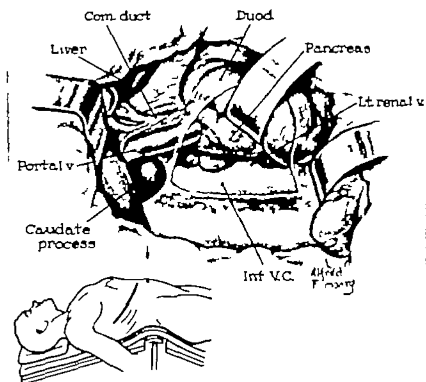
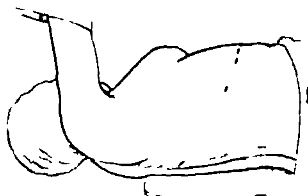
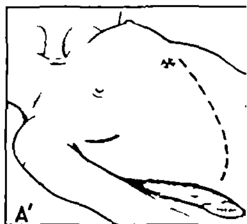
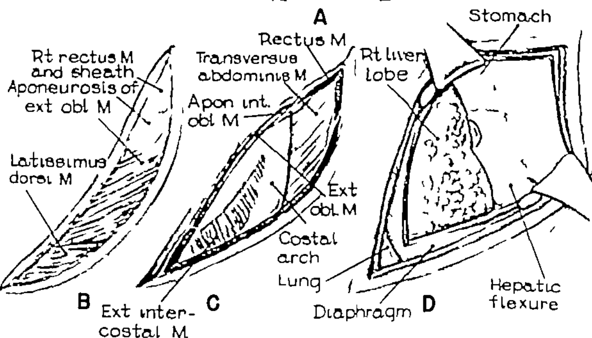


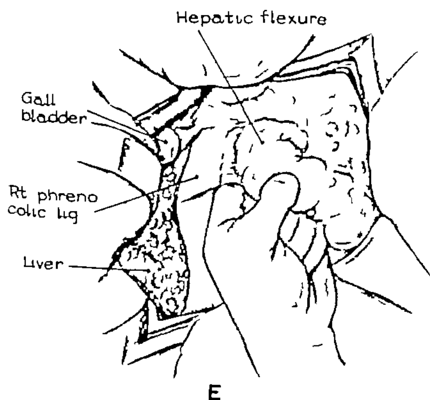
Fig 1




A'

A


Rt rectus M and sheath
Aponeurosis of ext obl M
Latissimus dorsi M
B
Rectus M
Transversus abdominis M
Apon int. obl M
Ext obl. M
Costal arch
Ext inter-costal M
C
Stomach
Rt liver lobe
Lung
Diaphragm
D
Hepatic flexure


Hepatic flexure
Gall bladder
Rt phreno colic lig
Liver
E

J The whole of the circumference of the inferior vena cava superior to the renal veins is completely mobilized, and its lumen is partially occluded by a Potts–Smith clamp However if desired, a Potts curved porta caval clamp may be used. The advantage of this type of clamp is that a longitudinal segment of the inferior vena cava may be occluded without the necessity of mobiliz ing the whole of the circumference of the inferior vena cava. The proximal transected end of the portal vein is turned downward toward the inferior vena cava preliminary to the performance of the venovenous shunt. The dotted line in the occluded seg ment of the inferior vena cava indicates the site of the incision for the anastomosis.

This type of clamp or one of the Beck Potts type is now preferred.

K. The posterior suture layer of the anastomosis is inserted. This is a continuous ever sion type of suture (silk, 00000) with intima to intima approximation. The suture is commenced from the "outside in" on the portal vein and terminates from the "inside out" also on the portal vein Between its commencement and termination, the suture proceeds from the inside out" to the "out side in" relative to the lumens of the portal vein and the inferior vena cava. Accord ingly the loops formed by the suture are always on the outside of the lumen of the vessel.

L. The posterior suture, a–a, is drawn taut, and the intimal surfaces of the portal vein and the vena cava are in close approxima tion None of the silk suture is exposed within the lumen.

M. A series of interrupted everting mattress sutures of silk (00000) is employed for the anterior layer of the anastomosis. All of these sutures are first inserted and then tied The mattress sutures at either end are tied first, and one of the long ends of each of these sutures is in turn tied to either end, a–a of the continuous everting suture of silk used for the posterior layer

N. The intervening mattress sutures are tied to complete the anterior layer of the anastomosis.

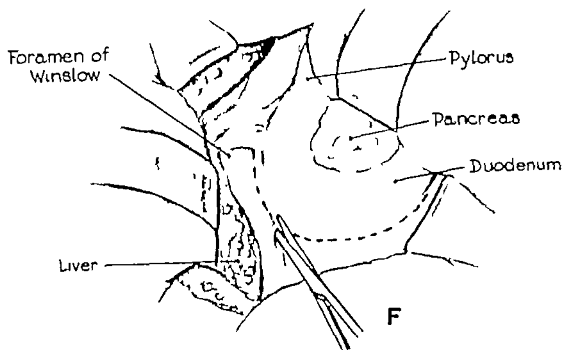
A single continuous over-and-over suture is now used routinely instead of the evert ing sutures as illustrated. However the mattress stay sutures at each angle are still employed The needle strand of each mat tress suture is continued as an over-and-over suture to terminate in the center of the anastomosis anteriorly

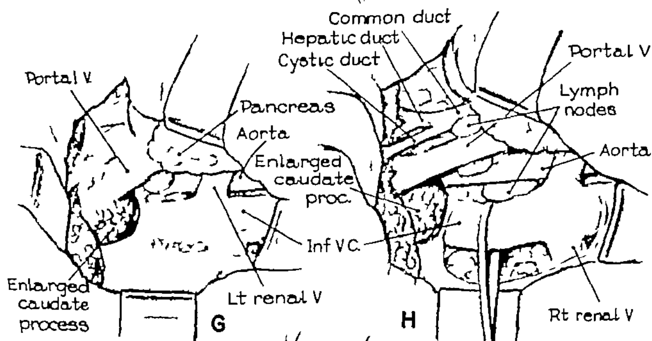
O The operative field upon completion of the end-to-side portacaval shunt is shown

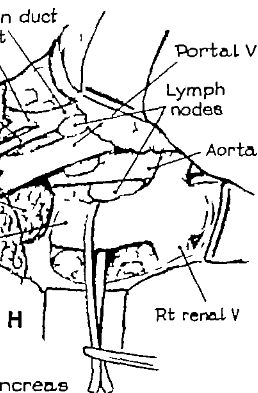
DISCUSSION—DRS. BLAKEMORE AND VOORHEES (CONT.)
identification and partial mobilization of the inferior vena cava. The second step is identification and mobilization of the portal vein The third step is the anastomosis of the portal vein to the vena cava.

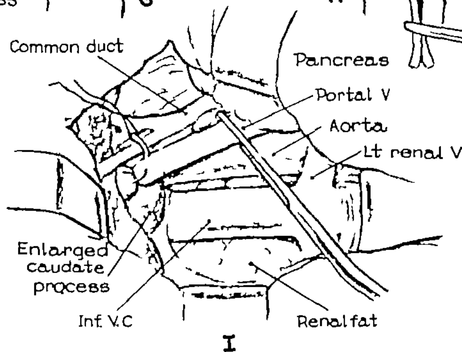
Step I (Fig. 1) The peritoneal reflection overlying the first and the second portions of the duodenum is incised along the greater curvature of the first and second portions of the duodenum By blunt and sharp dissection, the first and second portions of the duode num are rolled toward the midline When the under surface of the pancreas can be identified along the lesser curvature of the duodenum, the medial mobil ization of the duodenum has been sufficient With the duodenum in its medial reflected position, the vena cava lies immediately posterior to the area from *which the second portion of the duodenum was re* flected The overlying strands of areolar tissue can be divided with safety along the anterior midline of the vena cava If the right spermatic or ovarian vein is visible, the anterior mobilization of the vena cava has been begun too far caudad. For the purposes of the operation, it is usually sufficient to mobilize only the anterior and medial aspects of the vena cava from the level of the left renal vein to the caudate isthmus of the liver Mobilizing the right lateral aspect of the vena cava in this region is unnecessary and extremely hazardous because of the numerous veins coming from the adrenal gland and entering the vena cava directly It is also important to identify with preci sion the left renal vein since it will subsequently represent a landmark in selection of the site of anastomosis. In certain patients, hypertrophy of th caudate process may encroach upon the subsequen site of anastomosis, and, in these instances, the cau date process must be resected (Fig. 2) When this i the case, it is necessary to ligate two or more pairs o minute veins running from the caudate process to th vena cava. These are frequently unrecognized durin manipulation of the process and may be torn, givin rise to troublesome hemorrhage in an area difficult t control Once the caudate process has been free from the underlying vena cava, it can be cross clamped and resected Hemostasis is achieved b multiple vertical mattress sutures placed approxi mately 1 cm. from the cut margins.

Step 2. It must be remembered that, with the patient in a hyperextended left semilateral position the operator is usually looking at the right lateral aspect of the hepatoduodenal ligament, and, in this position, the common duct lies in an anterior location and the portal vein in a posterior location in the liga ment (Fig. 1) The peritoneal investment of the hepatoduodenal ligament is incised in the posterior right lateral aspect of the hepatoduodenal ligament from the porta hepatis to the greater curvature of the duodenum In making this incision care should be exercised to avoid cutting unnecessarily any recognizable lymphatic channels. Once the peritoneum is incised, the vein can usually be identified by finger dissection and palpation Upon identification, the


Foramen of Winslow
Pylorus
Pancreas
Duodenum
Liver
F


Portal V
Pancreas
Aorta
Enlarged caudate proc.
Inf V.C.
Enlarged caudate process
Lt renal V
G


Common duct
Hepatic duct
Cystic duct
Portal V
Lymph nodes
Aorta
Rt renal V
H


Common duct
Pancreas
Portal V
Aorta
Lt renal V
Enlarged caudate process
Inf. V.C
Renal fat
I

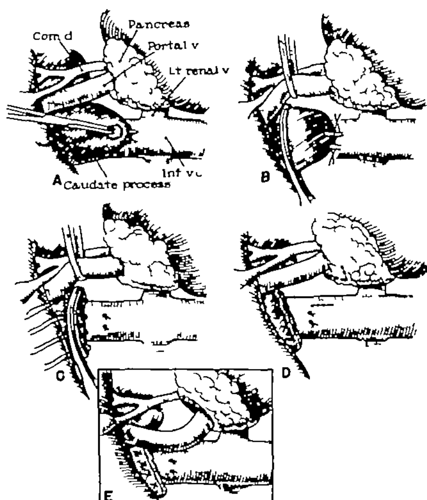

Com d
Pancreas
Portal v
Lt renal v
Inf vc
A
Caudate process
B
C
D
E

Fig 2

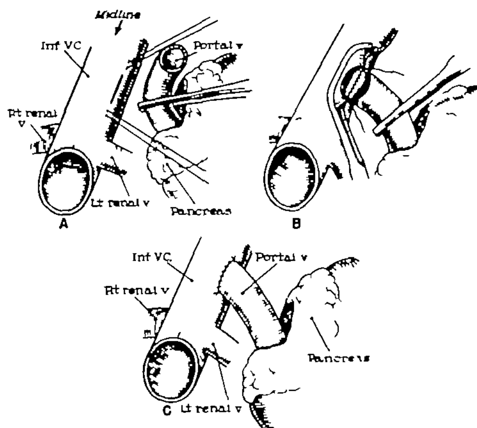
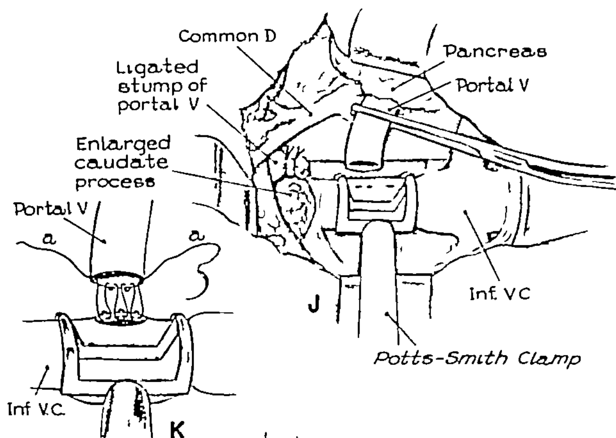
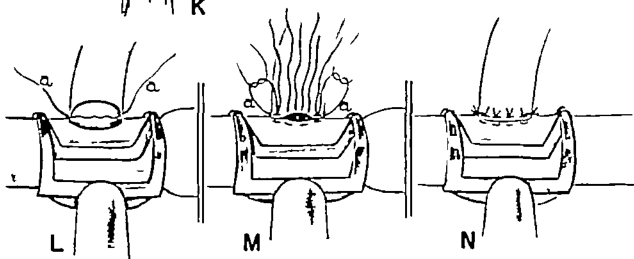
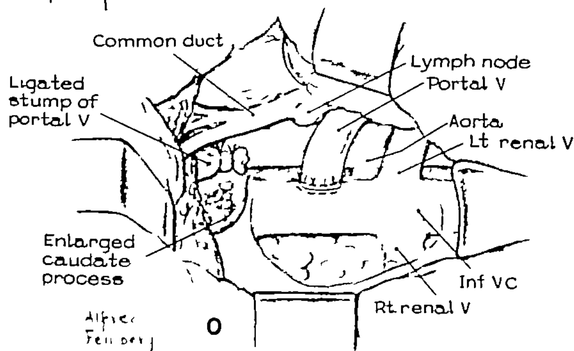

Midline
Inf VC
Portal v
Rt renal v
Lt renal v
Pancreas
A
B
Inf VC
Portal v
Rt renal v
Pancreas
C
Lt renal v

Fig 3


Common D
Ligated stump of portal V
Pancreas
Portal V
Enlarged caudate process
Portal V
a
a
J
Inf. VC
Inf V.C.
K
Potts-Smith Clamp


a
a
a
a
L
M
N


Common duct
Lymph node
Ligated stump of portal V
Portal V
Aorta
Lt renal V
Enlarged caudate process
Inf VC
Rt. renal V
O

DISCUSSION—DRS. BLAKEMORE AND VOORHEES (cont.)

and may not be recognized by a cursory examination It must be actively looked for

In those instances where side to-side anastomoses between the portal vein and the vena cava are deemed advisable because of a pressure rise in the portal system in excess of 150 mm. of saline following compression of the portal vein, the portal vein is not divided Contiguous surfaces of the vena cava and portal vein are marked by arterial sutures, the vena cava is grasped by a Beck-Potts clamp in a fashion similar to that previously described, and a 15 mm. diameter oval "window" is cut (Fig 2). The portal vein is temporarily occluded above and below the site of anastomosis by a simple double turn of umbilical tape, and a corresponding 15 mm. diameter oval "window" is cut in the previously marked site. The anastomosis is accomplished in precisely the same manner as that described for the end to-side anastomosis.

After completion of the portal vein-to-vena cava shunt, manometric pressures are again recorded in the portal system, with and without portal vein compression. In ideal circumstances, the pressure in the portal system should be less than 200 mm. of water pressure. If this pressure has not been achieved, the possibility of mechanical impediment to flow by distortion of the portal vein, or at the site of anastomosis, should be excluded by inspection. In the closure of the operative wound, no attempt is made at reperitonization or closing the retroperitoneal tissues over the site of anastomosis. The abdominal and thoracic portions of the wound are anatomically reconstituted. The abdomen is closed without drainage, and the chest cavity is closed over a large caliber catheter which is withdrawn at the conclusion of the chest closure after residual air and fluid have been evacuated from the cavity

vein should be dissected bluntly in the adventitial plane at roughly its midportion between the porta hepatis and the head of the pancreas. Following local circumferential dissection of the vein, a short piece of umbilical tape can be passed about the vein for the purpose of gentle traction. This serves as a useful method for avoiding unnecessary instrumentation of a vein subsequently to be used as a shunt. The dissection is carried cephalad to the porta hepatis. The bifurcation of the portal vein into the right and left hepatic veins should be identified. This represents the highest point of dissection, and at this time there are usually no significant venous tributaries which must be dealt with. The portal vein is mobilized caudad by sharp and blunt dissection to the level of the head of the pancreas. Two major tributaries to the portal vein, if unrecognized, may tear and cause troublesome hemorrhage. The first tributary is on the medial aspect of the portal vein and enters directly into the head of the pancreas. The second tributary is on the lateral inferior aspect of the portal vein, just beneath a collar of pancreatic tissue where the portal vein emerges from the head of the pancreas. Both tributaries should be identified and individually ligated by transfixion ligatures of 00000 braided silk. After mobilization of the portal vein, it is appropriate to make initial pressure readings in the portal system from a large branch of the gastroepiploic vein. Simple manometric readings, using the manubrial notch as the reference point, should be made with the portal vein open and then with the portal vein compressed. If the pressure rise following compression of the portal vein is in excess of 150 mm. of saline, then a side-to-side portal vein-to-vena cava anastomosis is advised. As the last portion of this second step in preparation for an end-to-side anastomosis, a ligature of heavy silk is passed about the portal vein at the level of the bifurcation into the right and left hepatic veins. The ligature is tied, and a second transfixion suture employing 00 braided silk is placed approximately 3 mm. from the primary tie. A rubbershod clamp that will occlude, but not crush, the vein is placed around the vein as it emerges from the head of the pancreas, and the vein is transected immediately proximal to the transfixion suture. Twenty to thirty millimeters of a solution of heparin containing 10 mg. of heparin in 100 ml. of saline is instilled in the portal vein proximal to the rubbershod clamp. 2-2

Step 3. An imaginary line coursing parallel to the vena cava on its anterior medial aspect, equidistant from the true anterior aspect of the vena cava and the true left lateral aspect of the vena cava, which may be indentified by the juncture of the left renal vein, is defined and marked by two arterial silk sutures as the future axis of the anastomosis (Fig. 3). The vena cava is tended and grasped by a Beck-Potts clamp. An oval "window" is then cut in the vena cava, corresponding in diameter to the fully distended portal vein. The anastomosis is placed as near to the liver as practical so that the angle formed between the portal vein and the vena cava will be an acute angle 45 to 60 degrees. A single layer anastomosis is achieved by a simple over and over suture of 00000 braided silk. It is desirable to exert some tension on the angle stay sutures during the anastomosis to avoid pursestringing the stoma. In the posterior suture line, care must be exercised to avoid dragging small strands of adventitial tissue into the suture line by the suture material. After completion of the anastomosis, the vena cava clamp is released first, and the portal vein clamp released second. Anastomoses in a low pressure system rarely leak seriously and minimal suture line leaks occurring shortly after the removal of the clamps should be controlled by simple finger pressure over the area. Unless the suture line leak is a serious one, reinforcing sutures should not be taken since they may cause distortion or constriction of the stoma. Once flow has been established in the newly formed shunt, the point of emergence of the portal vein from the region of the head of the pancreas should be carefully examined. Frequently a collar of pancreatic tissue will cause angulation or actual compression of the portal vein in its newly established course. If this collar exists, a wedge of pancreatic tissue should be excised (Fig. 4). This compression feature is an exceedingly important one

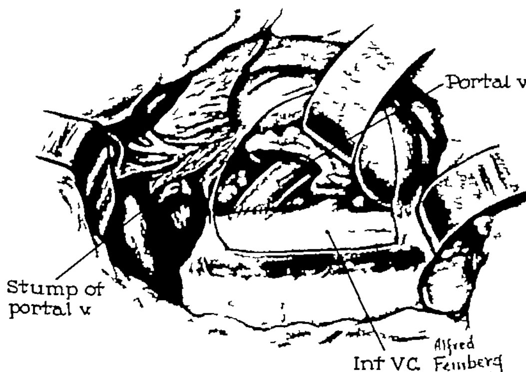


Fig. 4

SIDE TO SIDE PORTACAVAL SHUNT

A, B. The portal vein is cross-clamped caudad and cephalad by angulated Potts clamps Next, a tented segment of the inferior vena cava, cephalad to the renal vein tributaries, is occluded in a Beck Potts clamp Openings (2.5-3 cm.) are then made into the lumen of the portal vein and the lumen of the occluded segment of the inferior vena cava preparatory to their anastomosis A continuous suture of 00000 silk swedged on a small curved needle is used for the posterior layer This suture is started from the outside in at the caudad angle of the opening in the inferior vena cava (A) It is then continued as a simple over and-over suture to terminate from the inside-out at the cephalad angle of the opening in the portal vein (B) To facilitate its insertion, guy sutures (00000 silk) for traction are inserted in the anterior margins of the open *ings in the inferior vena cava and portal* vein (A, B)

The use of a continuous over and-over suture though theoretically objectionable because of the silk strands within the lumen, has proved most satisfactory in practice and is preferred to the continuous everting mattress suture

C. The posterior suture is drawn taut, and the respective cut margins of the portal vein and vena cava are firmly approximated.

D Interrupted everting mattress sutures are inserted at either angle of the anastomosis. The mattress suture at the caudad angle is tied, and its needle free strand is being tied to the caudad end of the posterior suture The insertion of the mattress suture at the cephalad angle is completed, and its needle *free strand will be tied to the cephalad end* of the posterior suture

Discussion—Dr. C Stuart Welch The illustrations show a technic for end-to-side portacaval shunt that deals with the incision, a minor part of the dissection, and the anastomosis. I shall deal with each of these items separately

First, the right thoracoabdominal incision shown is unnecessary for 90 or 95 per cent of portacaval shunts. Thoracoabdominal incisions consume time in opening and closing and also result in greater blood loss and thus greater need for replacement Patients with liver cirrhosis should have the least number of blood transfusions possible. It also is a fact that opening the pleural cavity invites pulmonary complications and morbidity I use a subcostal abdominal incision, as depicted in A The right side of the patient is elevated 30 off the table, and the incision is begun halfway between the xiphoid process and the umbilicus. It is then directed to the right under the rib cage extending beneath the twelfth rib in the costovertebral angle One indication for a thoracoabdominal incision is a very large liver

It is, of course, impossible for the author to depict the dissection because of the variability of the disease, but this is the most important and difficult part of the operation I first expose the inferior vena cava, because this maneuver is quite easy and establishes an important landmark.

Next I dissect the portal vein. The important point in this dissection is to know where this vein is. It is posterior and medial in the hepatic pedicle. In most cases there is no need to make a formal Kocher mobilization of the duodenum There is also no need to first expose the common duct or hepatic artery The portal vein can be approached directly by putting the right hand to the left of the hepatic pedicle and exerting pressure posteriorly and to the right at the same time that the left hand dissects out the portal vein The most annoying part of the dissection is encountered in dealing with the large vascular lymph glands that surround the portal vein and lie between it and the vena cava All of the tributaries of the portal vein are medial, and they vary in number from none to three or four They must be accurately secured. Once the vein is free it remains only to decide whether or not a nick should be made in the pancreas to allow a freer right angle swing of the portal vein to meet the vena cava. The next step is a high severance of the portal vein at its bifurcation Here I recommend a free tie of 00 silk, distal to which I place a suture ligature.

Relative to the anastomosis, there is little of importance to say An ellipse should be cut out of the vena cava I prefer an everting type of suture anastomosis. The clamp shown in the drawings is an awkward one and would seem to require unneeded mobilization of the cava. A Satinsky clamp or Thomas Smith intestinal clamp is much easier to use. Mobilization of the cava posteriorly and medially is unnecessary and may result in bleeding from lumbar tributaries. The posterior row of sutures need not be laid and then drawn the suture line can be made with continuous approximation. Most surgeons believe that an everting anastomosis is unnecessary and if they are correct, the anastomosis is that much easier At any rate, the anastomosis is the least difficult part of the operation

E, F The needle strands of the everting mattress sutures at either angle are continued as simple over-and-over sutures (E) to terminate in the center of the anastomosis anteriorly where they are tied to each other and the strands cut to complete the anastomosis (F) Just prior to completion of the anastomosis, the traction guy sutures, visible in E, are withdrawn

G, G_1 A completed direct side-to-side shunt, using interrupted everting mattress sutures, is shown (G_1) In some instances when a direct side to-side shunt is not feasible technically it may be effected by the interposition of an autogenous vein (superficial femoral) graft, the so called H graft (G)

DISCUSSION—DR. C. STUART WELCH. Anastomosis of the portal vein to the vena cava done by a tangential technic is the original Eck fistula and can be done instead of end-to-side portacaval shunt for the prevention of bleeding from esophageal varices. It also has, I believe, a preferential place in the surgical treatment of certain cases of ascites. Some discussion of the indications for this shunt is apropos, because there are some surgeons who never use it and admit of no indication for its use.

If the problem before the surgeon is simply to reduce splanchnic portal pressure in a patient who has survived a hemorrhage from esophageal varices, a simple end-to-side shunt with interruption of the portal vein suffices. I say this because there is no question that end-to-side anastomosis is much more easily performed. However a side-to-side shunt, if well made, is equally good functionally and is not harmful provided the anastomosis is not too large. If too large it predisposes to ammonia intoxication. *A shunt of 2 or 2.5 cm. is of sufficient size and need not be exceeded.*

The special indication for a side-to-side portacaval shunt is persistent and intractable ascites. The rationale of the use of this type of shunt in the treatment of ascites is based on the supposition that decompression of the liver may be obtained by retrograde portal blood flow Time does not permit a complete discussion of the cause of ascites. Suffice it to say there is evidence of out flow block in the liver and evidence that reverse or retrograde portal blood flow in a side-to-side portacaval shunt *can* prove beneficial. From the practical standpoint, the use of this type of shunt has cured patients with ascites. Although it should not be applied to all patients with ascites, it is difficult to lay down rules for its application. However in the surgical management of patients with ascites, a side-to-side shunt is believed superior to an end-to-side shunt.

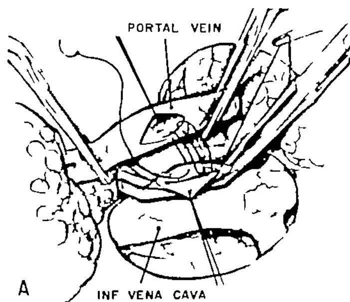
From the technical standpoint, several features bear comment. Nothing is said about the incision in the illustrations. The right side of the patient should be elevated about 30° from the horizontal and a large subcostal abdominal incision employed. A thoracoabdominal incision should not be used routinely It is time-consuming and the morbidity is high. It is only when one is dealing with a very large liver that a planned thoracoabdominal incision is needed The subcostal incision begins at the linea alba halfway between the xiphoid process and the umbilicus and extends under the twelfth rib to the costovertebral angle.

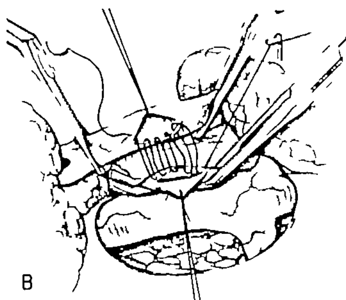
A side-to-side shunt is not technically feasible in all patients because of the distance between these two veins and the interposition of the caudate lobe. I would estimate that it can be done in 75 per cent of the patients. Two technical maneuvers are especially helpful in making a good side-to-side shunt (1) resection of the caudate lobe and (2) mobilization of the vena cava. "If the mountain will not go to Mahomet, Mahomet must go to the mountain." To effect this mobilization, the right renal vein must be loosened. If a side-to-side shunt adequate in size and without *tension or angulation is not possible it should not* be done. An end-to-side is a good alternative. I mention this because a poorly made side-to-side shunt is doomed to failure by thrombosis.

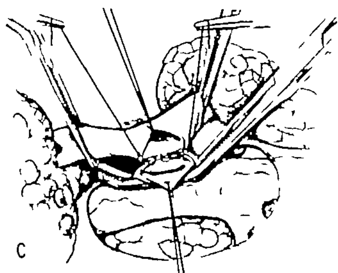
The illustrations depict a side-to-side shunt that is very easy to do, and I would warn that the technical difficulties described previously bear consideration. It is good to take ellipses out of both the portal vein and the vena cava as a preliminary to the anastomosis. I also favor an everting stitch because it leaves so little suture material exposed within the lumen.

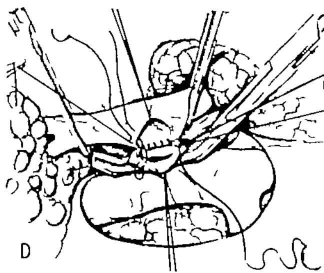
In some instances a side-to-side shunt can be done by using a high transverse incision in the inferior vena cava when it would be impossible with a longitudinal incision as shown in the drawings. Then Satinsky clamps are applied a right angles to the cava.

Finally I would never recommend an H shunt using an autogenous femoral vein. In such grafts the incidence of thrombosis is high. It is better to do an end-to-side anastomosis even though a side-to-side would be more desirable if the former seems too difficult. In some instances, ascites has been relieved by an end-to-side portacaval shunt.


PORTAL VEIN
A
INF VENA CAVA


B


C


D

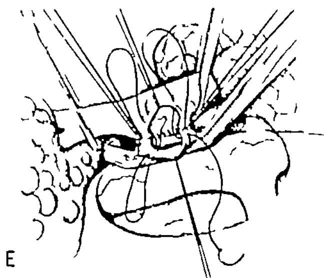
LEFT TRANSAXILLARY TRANSPLEURAL THORACIC SYMPATHETIC GANGLIONECTOMY

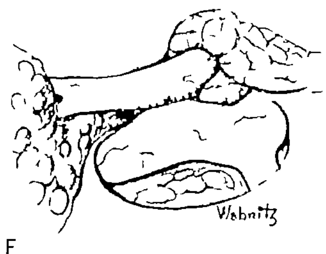
A. The patient is placed in the direct right lateral prone position and the transaxillary incision is indicated (broken line)

B. The left pleural cavity is entered, and the rib cage retracted to expose the opening in the posterior parietal pleura and the start of the mobilization of the sympathetic chain and ganglia. The neighboring intrathoracic structures are visible The broken lines in relation to the lower borders of the second and third ribs indicate the incisions to be made in the parietal pleura for the exposure of the second and third thoracic nerves.

C. The segmental resection of the sympathetic chain and ganglia (D2, D3 and D4) and the third intercostal nerve is completed The second intercostal nerve is transected, and its clamped posterior segment is being mobilized to expose its anterior (motor) and posterior (sensory) roots.

D The anterior root is transected, and the posterior root is being severed with scissors just distal to its sensory ganglion. In this dissection the subarachnoid space may be entered and cause a leakage of spinal fluid. In the experience of the author the inclusion of the segmental resection of the somatic nerves (T2 and T3) has not been associated with an improvement when compared with the clinical results obtained when this is not done.





Sup fem vein graft

Lymph node

Rt. kidney

Rt renal vein

Inf vena cava

G₁

G

RIGHT TRANSAXILLARY TRANSPLEURAL THORACIC SYMPATHETIC GANGLIONECTOMY

A. The patient is placed in the direct left lateral prone position, and the flexed right upper extremity is elevated and supported above the head. The transverse skin incision (broken line) overlies the third intercostal space and extends from the lateral border of the pectoralis major muscle to the anterior border of the latissimus dorsi muscle

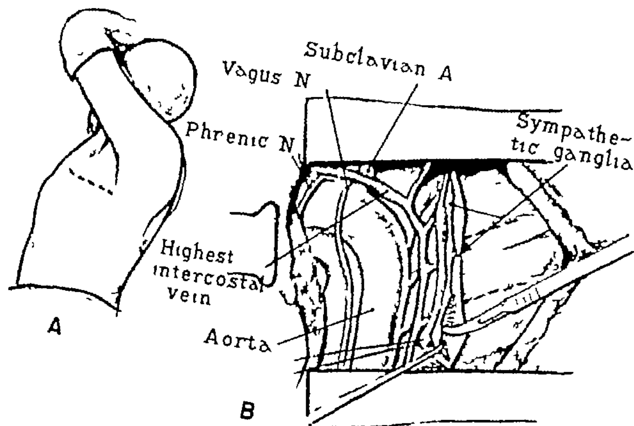
B. The incision is deepened through the subcutaneous fatty tissue layer to expose the line of incision (broken line) in the axillary fascia.

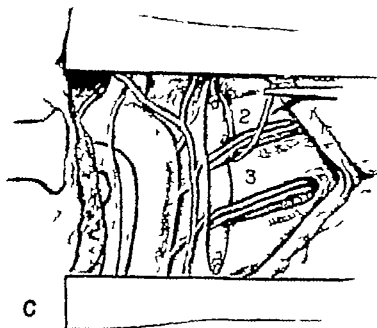
C. The transected tissue layers are retracted, and the lateral cutaneous branch (intercostohumeral) of the second thoracic nerve with an accompanying vein are shown within the surrounding fatty areolar tissue. A lymph node between the nerve and vein is faintly outlined.

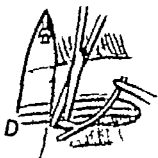
D The fatty areolar tissue is cleared to show clearly the lymph node and the intercostohumeral nerve in relation to the anterior serratus muscle The ligated ends of the severed vein are also visible.

E. The nerve is retracted anteriorly and the incision in the anterior serratus muscle is indicated (broken line)

F The cut margins of the muscle are retracted, and the periosteum overlying the third rib is incised (broken line) The blood vessels arching upward from below the fourth rib may be seen.


Subclavian A
Vagus N
Phrenic N
Sympathetic ganglia
Highest intercostal vein
Aorta
A
B


2
3
C


D

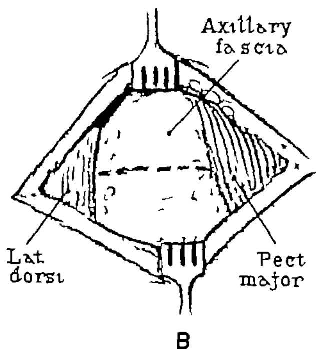
G, H. The lower half of the periosteum is separated from the third rib (G) and the left index finger is inserted between the separated periosteum and the rib (H) to mobilize it by blunt dissection from the underlying endothoracic fascia and parietal pleura (Brock technic)

I, J K. An opening previously made into the pleural cavity is extended by scissor dissection (I) and the adjacent ribs (third and fourth) are retracted (J) The cut margins of the posterior parietal pleura are retracted with guy sutures of silk (0000) and the thoracic sympathetic chain and ganglia in relation to the adjacent structures are visible (J K)

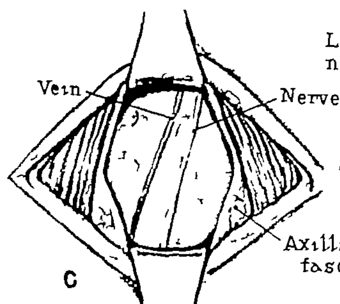
L. The thoracic sympathetic chain is transected between a silver clip (Cushing) and clamp caudad to the fourth ganglion and is then mobilized cephalad by sharp dissection using a curved knife blade (No 12)



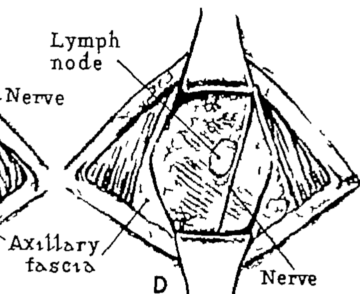
A


Axillary fascia
Lat dorsi
Pect major

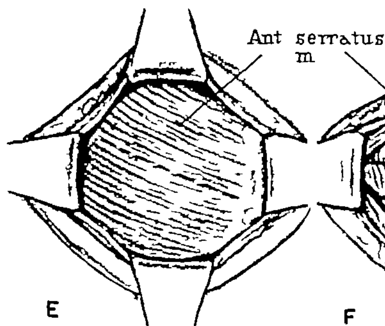
B


Vein
Nerve
Axillary fascia

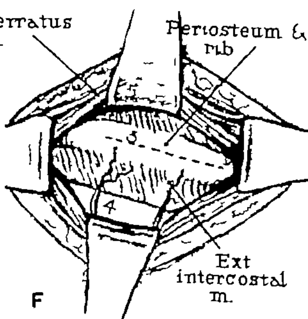
C


Lymph node
Nerve

D


Ant serratus m

E


Periosteum & rib
4
Ext intercostal m.

F

LEFT LUMBAR SYMPATHETIC GANGLIONECTOMY

A. The patient is placed in the supine position, and the left side is elevated on a pillow support to approximately a 25 degree angle to the horizontal.

B. Traction with a multipronged (rake) retractor is maintained upward on the upper flap as its mobilization is completed by scalpel dissection. The lower flap was previously mobilized in like manner

C. The outer angle of the incision is also mobilized by scalpel dissection until the musculature of the lateral abdominal wall is readily visible

D The mobilized skin margins are retracted, and the incision in the external oblique muscle in the direction of its fibers is visible. *This incision is always made through the* muscle fibers and never through the aponeurosis, which is located medially

E. The separated fibers of the external oblique muscle are retracted to expose the opening *in the internal oblique muscle layer through* which the underlying fibers of the transversus abdominis muscle are visible. The internal oblique is the thickest and the transversus abdominis is the thinnest of the *three muscle layers that are to be separated.*

F The muscle fibers of the internal oblique are separated by finger dissection, and care is observed to avoid avulsion of the underlying intercostal nerves between which an opening is made through the fibers of the transversus abdominis muscle. The dissection of this muscle is begun laterally and continued medially to lessen the possibility of opening into the peritoneal cavity The opening in this muscle layer exposes a portion of the irregular line of overlap of the retroperitoneal fat on the lateral parietal peritoneum.

G The muscle layers are retracted, and the transversalis fascia overlying the retroperitoneal fat is severed by scissor dissection. A herniation of a portion of the retroperitoneal fat through the opening made in the trans*versalis fascia is visible*

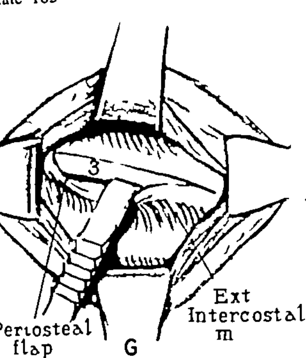
Discussion—Dr. Gerald H Pratt We have found spinal anesthesia not only safe, but one which, by its muscle relaxation, makes the operation technically easier The level of anesthesia must be to the fourth or fifth dorsal nerves. A hypobaric solution permits the operative area to be elevated at once. The patient is placed on the table at a 45 degree angle to the operator by placing a sandbag underneath the hip and shoulder The table is then broken, and the band on the operator's side is raised high above the patient's head to pull the lower ribs out of the way In this position, the space between the last ribs and the crest of the ilium, which is normally only about 2 inches, can be widened to 4 or 5 inches, and the lumbar spine is brought quite close underneath the operative incision

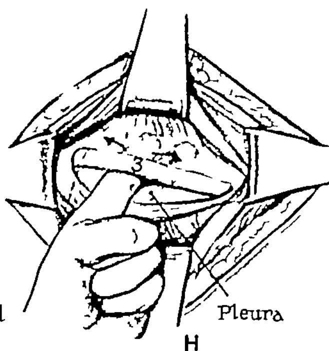
We use approximately the same incision for lumbar sympathectomy as the author a transverse one made in the line of the skin cleavage at the level of L 2 If the separation of the external oblique muscle the most restricting of the muscles, is extended longer than that through the other lateral abdominal muscles, the wound can be moved to excise a ganglion found anatomically higher or lower than usual.

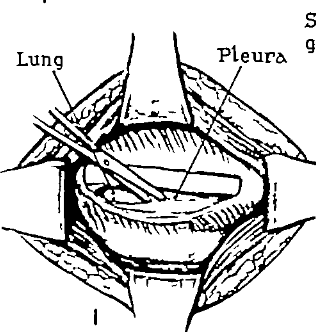
On the transversalis muscle and fascia lie the intercostal nerves and blood vessels. These nerves and vessels can be protected by making the transversalis incision between them, thus preserving the nerve supply to the muscles and also reducing the incidence of a painful neuritis. If the level of spinal anesthesia is slightly lower than desired, these nerves can be injected with procaine to avoid the addition of a general anesthesia, which we consider to be an added danger

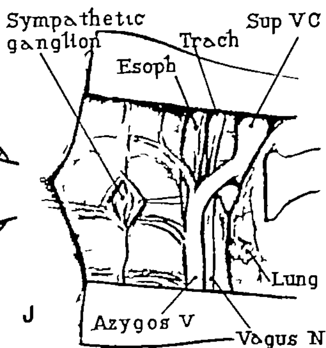
Mounted damp sponge sticks are adequate dissectors for moving the peritoneum and its contents forward without injury to the peritoneum One must avoid dissecting behind the iliacus or between the iliacus and the psoas muscles.

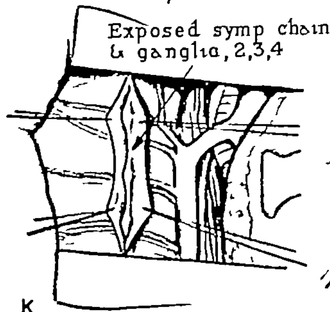
Any dissection of the vena cava must be gentle since its lumbar branches are thin and easily torn. We dissect the upper part of the chain first follow-

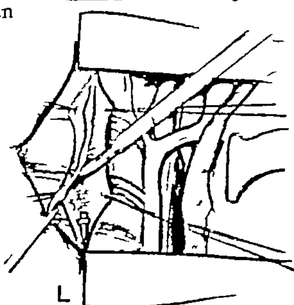

3
Periosteal flap
Ext Intercostal m
G


3
Pleura
H


Lung
Pleura
I


Sympathetic ganglion
Sup VC
Trach
Esoph
Lung
J
Azygos V
Vagus N


Exposed symp chain & ganglia, 2,3,4
K


L

H. By blunt digital dissection in the retroperitoneal fat, the peritoneum and the adjacent intraperitoneal viscera are displaced toward the midline. During this dissection, the important landmark is the psoas major muscle, which is located more anteriorly than one generally assumes The tissue dissection is continued anteriorly and medial to this muscle otherwise, troublesome technical difficulty may ensue

I. The peritoneum and the related intraperitoneal viscera are retracted toward the mid line to expose the left ureter which overlies Gerota s fascia The ureter is always first identified before being retracted from the operative field. The adjacent related structures are readily demonstrable.

J The ureter is retracted medially The line of the incision to be made in the fascia of Gerota is indicated by the dotted line.

K. The incision in Gerota s fascia is completed, and, by blunt dissection with a long tissue forceps (deleted for clarity) in the underlying fatty areolar tissue, the lumbar sympathetic trunk and the lumbar vessels are exposed along the anterolateral surface of the vertebral column Further identification of the sympathetic trunk may be obtained by digital palpation against the sides of the lumbar vertebrae. The genitofemoral nerve frequently mistaken for the sympathetic trunk, may be seen coursing downward and lateralward along the medial aspect of the psoas muscle This nerve is white in color nonganglionated, easily mobile always on muscle (psoas), and directed downward and lateralward. Contrariwise, the lumbar sympathetic trunk is yellowish–white in color ganglionated, and located on the anterolateral aspect of the bodies of the lumbar vertebrae and never on muscle Furthermore, it is taut and relatively fixed in position by the attachment of the rami communicantes to their respective ganglia and is the most posteriorly situated structure along the vertebral column. Finally its direction is downward and slightly medialward. These anatomic differences should serve to differentiate the genitofemoral nerve from the lumbar sympathetic trunk.

L. The sympathetic trunk is mobilized on a nerve hook, and, with upward traction maintained, the anchoring rami communicantes are severed with a curved knife blade (No 12).

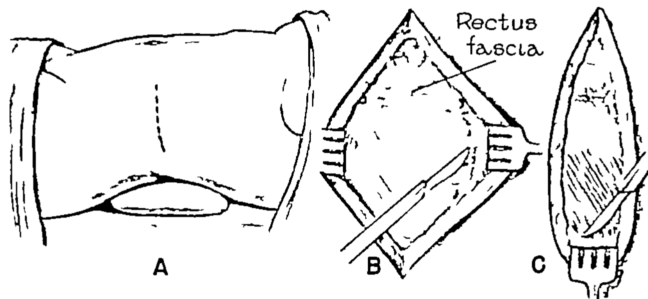
Discussion—Dr. Pratt (cont)

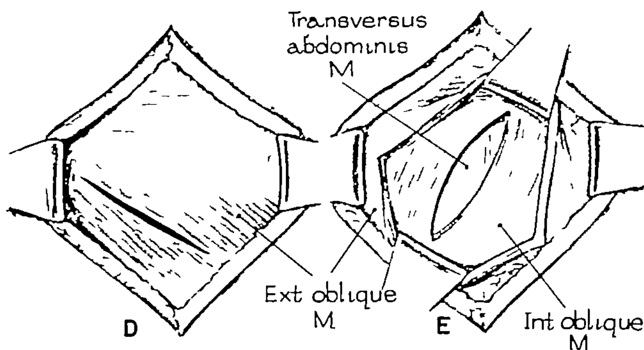
ing it as high as possible, usually to the diaphragm. To increase the extent of sympathectomy we avulse or exerese it from its surrounding tissue, and, if the pull on the chain is directly in the line of its fibers, the maneuver does not tend to lacerate any vessels.

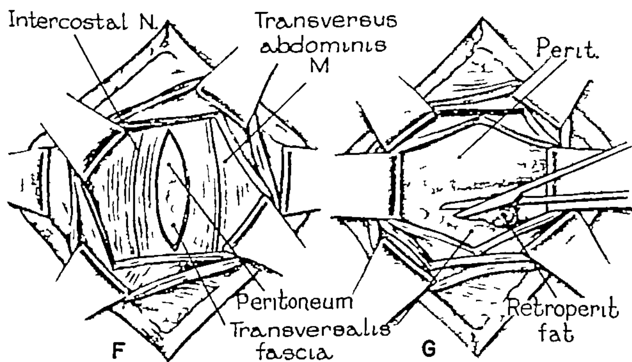
The so-called fool's sympathetic, the genitofemoral nerve, is seen lying on the muscle in contradistinction to the chain which is in close approximation to the periosteum of the vertebrae with its enlargements (ganglia) The chain has a characteristic feeling to the palpating finger We do not remove any structure as a chain until it is further identified manually by rubbing it against the vertebrae and feeling its cord, not unlike the vas deferens

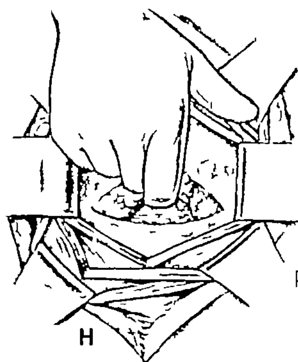
The artist s drawing depicts the sympathetic chain as a single nerve with ganglia More often it is found as a plexus of nerve fibers with several communicating branches entering the main trunk above and below the ganglia We feel it is important to remove all such fibers, even those that cross to the other side Thus the lumbar sympathetic nerves are a plexus and not just a nerve with ganglia There can be from two to eight ganglia in the lumbar area, and all the fibers should be removed in order to do a complete operation In many instances, a repeat lumbar sympathectomy has been effective, the preceding operation having only removed one or two ganglia with a continuation of sympathetic effect by collateral sympathetic nerves. Identification of the upper and lower ends of the resected sympathetic chain by a silver clip is practical, as the author has pointed out, and also prevents an annoying hemorrhage from an accompanying vessel. The author brings attention to the variations of the anatomy in the right and left sides and the danger of injuring vertebral veins. The removal of the underlying chain by dividing it at the overlying vein and teasing it under the vein is a safe measure, if done carefully While these lumbar veins can be clamped and divided, an attempt at their ligation is fraught with danger Serious complications have developed from trying to ligate small lumbar veins Silver clips are best used at this stage for hemostasis These veins in themselves are small, but they open directly into the vena cava. If these veins tear one has a laceration in the wall of the vena cava, and the small vein stump retracts and is a hole in the cava In cases of serious hemorrhage, packing is advisable at least until blood for transfusion is available This venous bleeding can be controlled by a hemostatic pack, while a laceration from traumatic tearing of a hastily applied clamp on the vena cava might be serious or even fatal.

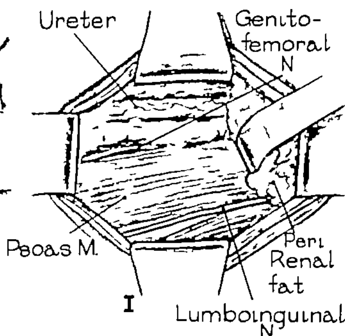
In closing the wound, one should again be careful to prevent inclusion of the nerves on the transver

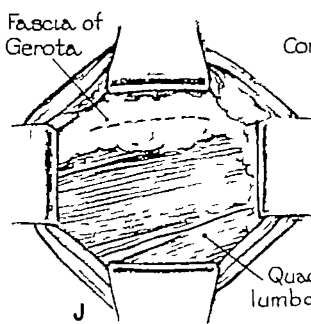

Rectus
fascia
A
B
C

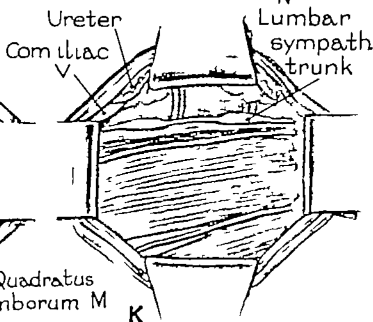

Transversus
abdominis
M
Ext oblique
M
Int oblique
M
D
E

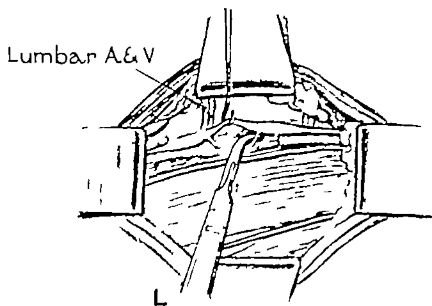

Intercostal N.
Transversus
abdominis
M
Perit.
Peritoneum
Transversalis
fascia
Retroperit
fat
F
G


H


Ureter
Genito-
femoral
N
Psoas M.
Peri
Renal
fat
I
Lumboinguinal
N


Fascia of
Gerota
Quadratus
lumborum M
J


Ureter
Com iliac
V
Lumbar
sympath
trunk
K


Lumbar A&V
L